Metals and Alloys

The Engineering Magazine of the Metal Industries

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This Month

Every Month

Metallurgical Engineering Digest


They Also SERVE..
-IN THE
INCREASED PRODUCTION
OF
PATTERSON
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THE PATTERSON FOUNDRY & MACHINE CO.
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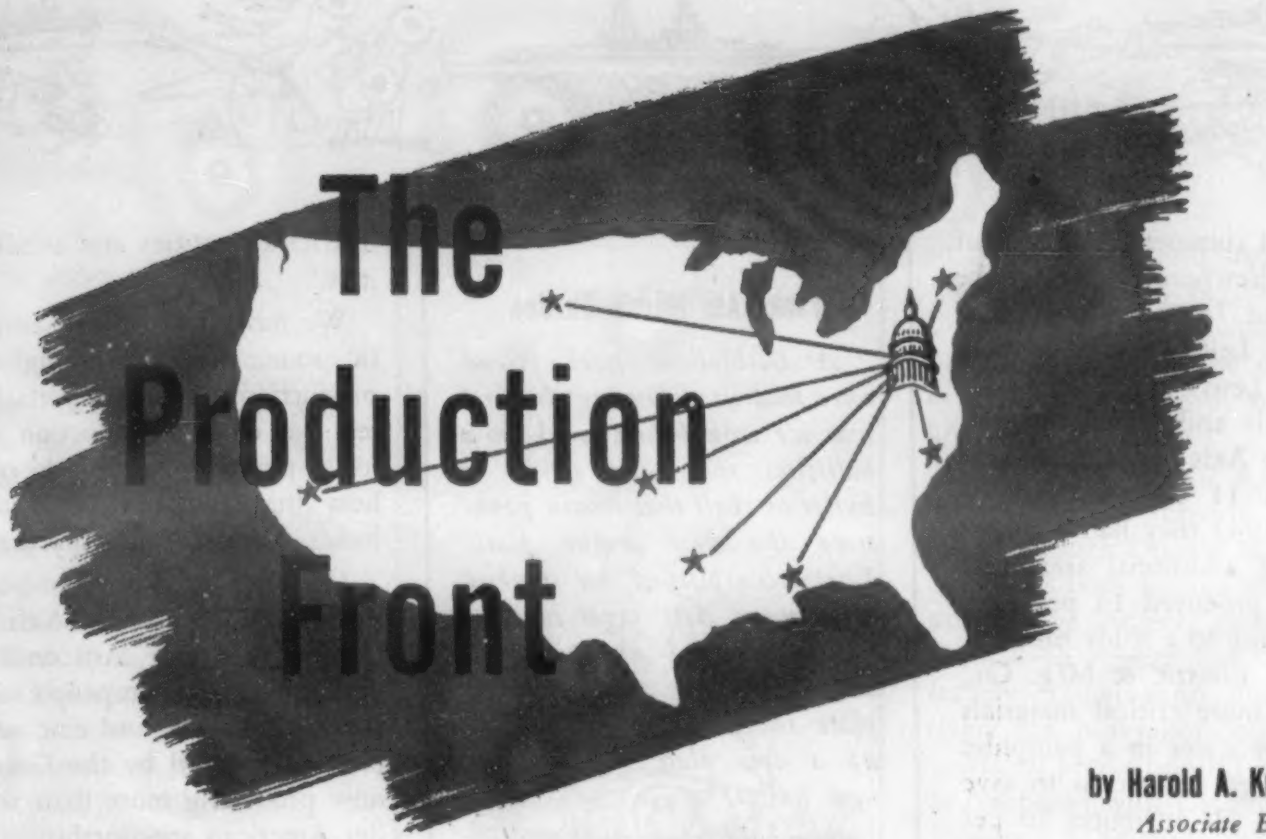
The Production Front



by Harold A. Knight
Associate Editor

March, a normal production record month, crashes through again.... Pig iron, steel ingots, steel plates at new highs.... Shipbuilding now largest steel outlet.... Claims Axis has more critical materials than our side.... Swastika a "double cross" for German middle class.... Stainless steel worthy of better name.... Should 40- to 50-hour week be tops?... Novelties help do away with rutty routines.

Private Jones meets the general.... Trend to bombers means fewer planes.... Must cut carbon steels pie into smaller pieces.... Metals and plastics, rival glamour girls.... Lessons in packaging metals for overseas.... Gold plate steel shells?... Gold production flops.

Production Days Aren't Over

Although it has been stated in high official quarters that by Fall we will have passed the peak of our war production except for airplanes and escort vessels, the need for more and more production has been emphasized in recent weeks. General MacArthur and Australian officials have appealed urgently for more airplanes, which implies more ships to transport them, especially for fighter planes. Each one of the United Nations, large and small, put ever-increasing pressure for more war items under Lend-Lease.

Recently, Donald Nelson revealed that airplane production is still the major subject of war planning and that there is no thought of reducing the Government's goal of approximately 100,000 warplanes in 1943. This is twice as many as were turned out in 1942, with about four times the total tonnage, representing a greatly increased number of heavy bombers.

Just One Record After Another

That we have become by no means decadent in our production is attested by new high records and plans for the same. March pig iron production was an all-time top at 5,247,792 tons. In March we turned out 7,670,187 net tons of ingots and steel for castings, or 90,000 tons more than were produced in the previous best month, October, 1942.

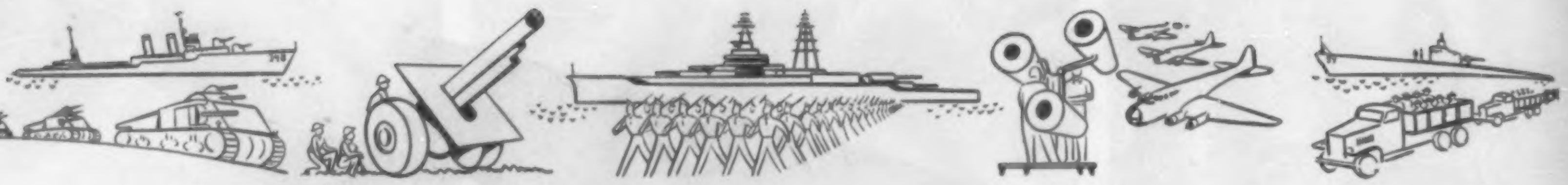
On the same day this record was announced, it was also divulged that steel plate production in March was an all-time high. And, speaking of plates, it is revealed that for the first time in history shipbuilding was the No. 1 steel consumer in 1942, taking 9,425,000 net tons, or 16 per cent of the total compared with 4 per cent in 1941 and 2 per cent in 1940. In recent normal peace times the automobile industry was head and shoulders above all other steel consumers, whereas a generation ago railroads held that place.

The quota for Lake Superior iron ore production in 1943 was originally 95,000,000 tons, but this goal was reduced to 91,000,000 on May 6 because of the late ice breakup.

Steel ingot production during the first quarter of 1943 was 21,920,278 tons, or 900,000 tons ahead of the same era of 1942. Production for 1943 might be 90,000,000 tons against 86,029,921 tons last year, since new capacity goes into operation frequently.

But How Do We Stand on Materials?

Our ability to continue to make production records depends markedly on our access to raw materials. Within their boundaries the United States and the British Empire accounted for about 57 per cent of world production in 1939. To this



may be added commercial control of production elsewhere, bringing the total to around 75 per cent. So concludes C. L. Leith, J. W. Furness and Cleona Lewis, in a study of world minerals and world peace.

In 1939 the Axis powers produced a little under 11 per cent, but by the close of 1942 they had acquired the control of additional areas that in 1939 had produced 14 per cent.

Yet, according to a study made by Westinghouse Electric & Mfg. Co., the Axis has more critical materials than we do, it states in a pamphlet designed to urge Americans to save what we have. It attributes 50 per cent of the world's steel to the Axis, 17 per cent of the copper, 65 per cent of the tin, 58 per cent of the aluminum, 56 per cent of the pig iron, 35 per cent of the tungsten and 68 per cent of the magnesium.

Peeking at the Axis Production Front

Let's take a glimpse of the "Production Front" of the Axis. Because of war secrecy, they will be only fragmentary scenes and by no means of bird's-eye proportions.

Germans admit that exploitation of Norwegian industry and resources has met with increasing difficulties and resistance. Thus, the planned expansion of the Norwegian power and aluminum industry has failed to materialize successfully.

In German-occupied countries, standard work weeks in industry range from 56 to 66 hours, while the average week for German agriculture in 1942 was 78.8 hours. An important part of the "total mobilization" plan for Germany is reflected in the steady and marked increase of power by the German SS in the occupied countries at the expense of the native Nazi and Quisling movements.

Swastika Proves a "Double Cross"

The Nazi swastika has become the symbol of a "double cross" for scores of thousands of German businessmen, retailers and middle class enterprises, as the Office of War Information expresses it. The total mobilization plan has grown from an emergency wartime measure to a social and economic landslide in which the small businessman and the German middle class are the conspicuous victims.

At least three-fifths of all the retail stores will be closed as "not absolutely essential to the war effort." Yet, in 1920 Hitler had said: "We demand creation and maintenance of a healthy middle class — and that extreme consideration shall be given to all small purveyors to the state, district authorities and smaller localities."

Tanks Are Merely Turtles

A Bethlehem steel friend once told us: "During the first war we would first work in a ballistics shop and devise a bullet or shell that would penetrate the best armor plate. That accomplished, we smoked a 'Between Acts' cigar in celebration, packed up our tools and went over to the armor plate shop, where we brewed up a new plate to stop our new bullet."

It would seem that bullets are again King. Two months ago an artillery officer at Aberdeen, Md., confided that "tanks are on the way out." The marriage of the German tank and Stuka dive bomber is no longer happy. Superior Russian guns have held Nazis in check. They were guns again that made Rommel take a 1500-mile walk.

The German Mark VI's have an Achilles heel. The American "bazooka," a veritable Buck Rogers rocket, makes the lone infantryman superior to a skilled tank crew, the bullet melting a hole through thick plate.

So, will we cut down our tank production? Or are those Bethlehem men back in the plate shop?

We have heard from semi-authentic sources that bombing of Axis production and transportation centers has curbed production from 15 to 20 per cent, but we do not know how that compares with our own losses from German submarines.

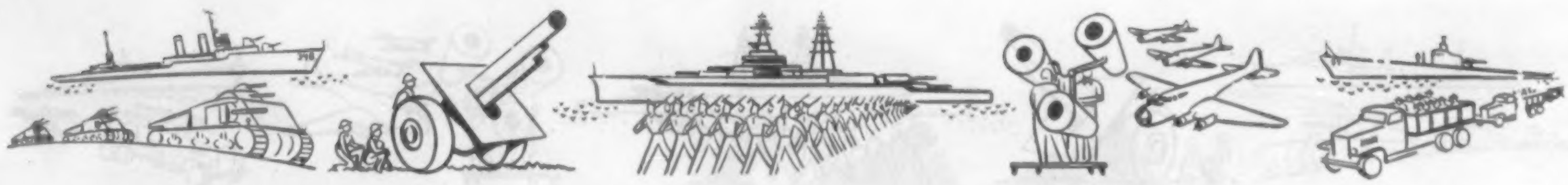
Occasionally we hear something distinctly favorable to Axis production. Thus, an Anaconda friend tells us that the company's subsidiary producer of coal and zinc in Polish-Silesia, captured by the Germans, is now producing more than when under American sponsorship.

Let's Up-Grade Stainless Steel

Perhaps the most intriguing metallurgical idea that has come to us during the month — not the most important — is that "stainless steel" has been under-named. It will be revealed after the war how it saved the day in an important application. The point is that "stainless" is too weak a nomenclature for a metal which, besides resisting corrosion as does the lowly kitchen knife, has many other magnificent qualities. We propose something in the class of "aqua regia," the supreme combination of two acids that dissolves most everything. Something like "Rex" metal, for example — king of them all.

On the topic of labor, another vital element on the production front, James F. Lincoln, president of Lincoln Electric Co., Cleveland, presents an interesting theory — at least it is strikingly expounded. The gist is that the mere working of long hours does not mean a proportionate large production.

"Experience shows that 12 hours a day does not produce as much as eight hours; that six days' work out of seven, other things being equal, produces more output than seven days continuously. This is not theorizing; this is the result of endless research." Mr. Lincoln suggests that if the worker uses his leisure correctly so that he comes to work fresh, 50 hours is perhaps maximum



for best production — possibly the key figure is under 40 hours.

Novel Ideas Eliminate the Humdrum

We have run across some novel ideas in a month — not always heavyweight material — some "funnies" in color on "Absentee Al" and "Careless Charley," for instance, put out by Morale Building & Absentee Reduction Service, 52 Vanderbilt Ave., New York, in the form of a series of booklets that show with more or less subtlety how absenteeism and carelessness slow up war effort.

Imagine you, a salesman or his equivalent, have just arrived in the reception room of the Lycoming Div., Aviation Corp., Williamsport, Pa. A receptionist, who uses a certain dentifrice twice a day and sees her dentist twice a year, hands you a little "Greetings" folder, which gives much pertinent information, such as names and positions of plant personnel, instructions about the company parking lot data about the company parking lot, data about ter of town — everything, in fact, that you need to know, except the weather, which is a military secret.

Still in the novel idea class, perhaps not new, is the specially-equipped mobile laboratory of the Bureau of Mines to assist the beehive coke producers. It visits the various yards, making rapid analysis of coal and coke samples to facilitate production of high-grade metallurgical coke of uniform quality.

A Case of Tea (?) For Two

We are glad industrialists can still laugh at a good anecdote. We clipped a story from that readable little potpourri of ideas, the "Houghton Line," and mailed it to our son in the Army Air Corps. We have to tell it from memory, therefore.

A soldier in ill-fitting uniform failed to salute a general. The officer stopped and asked: "How long have you been in this camp?" "Four hours," the rookie replied. "You must salute your superior officers. I am commandant of this camp. I don't care personally, but a second lieutenant might make trouble for you." "Glad to meet you, General. Meet Private Jones," said the rookie as he reached to shake hands. Conversation continued, the private getting in deeper and deeper. At length Private Jones pulled out a bottle from his hip. "How about a little swig, Gen.?" That was too much, and the General bellowed for the Corporal of the guard. "Pipe down, Gen., don't bring all the boys around. I've only got enough for us two in this bottle."

Metal Cavalry

by V. M. McConnell

In speedy, spunky metal tanks
The Yankees like to ride,
So they can smack
The Heinies flanks
And pot his guns
And pelt his ranks
And pull his nose
And other pranks
And come back safe inside.
Such metal work
Deserves our thanks
And everlasting pride.

Aircraft Program Revised Downward

Production estimates of 108,000 aircraft for 1943, somewhat less than the President's announced goal of 120,000 for the year, appear to be down again to 90,000. But in terms of weight, cost and manhours, the 90,000 will be a bigger task than the industry had anticipated for the 120,000 figure because of the larger percentage of 4-, 3- and 2-engine units.

Lt.-Gen. William S. Knudsen verified the 90,000 recently in Chicago, and Chairman Donald M. Nelson of WPB has been talking about 96,000 units. The industry produced about 48,000 in 1942, but these were largely trainers and included relatively few heavy bombers.

March production hit about 6,000, as compared with December's 5,500, January's 5,000-odd, and February's 5,500. The 8,000 per month mark is expected to be reached by midyear, when several new models will be coming off the production lines, according to Army announcements.

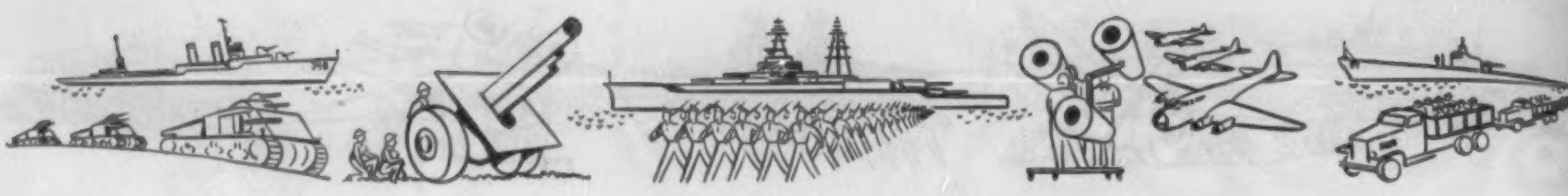
Secretary of Commerce Jesse Jones recently announced that the Government had financed plants and facilities for the manufacture of aircraft, engines, accessories, and parts to the sum of $2,640,000,000; aluminum facilities totaling $725,000,000, and magnesium $410,000,000. That totals 3 and 3/4 billion dollars. As to the first item, Congress was told recently that three new engine manufacturing plants, costing almost $300,000,000, are nearing completion.

CMP Cuts Garments to Fit Cloth

Sixteen claimant agencies have put in requests for 20,830,100 tons of carbon steels for the third quarter, against an estimated supply of 14,450,000 tons. Thus, the Controlled Materials Plan has come face to face with the first phase of its task: Cutting.

WPB Chairman Donald M. Nelson told METALS AND ALLOYS during a recent press conference that he was surprised that the estimated requirements was so much above the prospective supply, but had every confidence that each of the 16 claimants would be able to revise their requirements downward to fit.

He pointed out that many industries, particularly those in the metal



fields, had made some surprising advances in conservation. Both the reduction of scrap and rejects have been large contributors.

Speaking of carbon steel, reports from Pittsburgh indicate, however, that inspectors are becoming extremely careful in view of the recent Carnegie-Illinois plate troubles and the continuing Federal Grand jury investigation, and the Truman Committee activity in the Nation's steel capital. This will mean more rejections than usual, and will curb current plate production under the all-time record of 1,167,679 tons during March.

"Champ" Metals Vs. "Kid" Plastics

Plastics versus metals was the topic of a one-man debate by Dr. A. Allan Bates, manager of the Chemical & Metallurgical Department, Westinghouse Research Laboratories, East Pittsburgh, Pa., before the Cleveland section of the American Institute of Electrical Engineers.

"More metals will be used in the future because their partnership with plastics will make possible many new products," he said. In some cases the two will put on gloves as rivals until the better one wins. Many items will be metals for years to come, such as automobile crankshafts and valves, electric transmission lines, electric motor armatures and things that need conductivity and stability at very high temperatures.

Plastics have a knock-out punch when it comes to esthetic appeal, corrosion resistance, lightness with strength — and they can be made with coal, air, water, wood and cotton.

The cost factor often gives metals the advantage. Plastics cost from 20 cents to $1.00 a lb. While steel can be produced for a few cents a lb., copper at 12 cents and aluminum at 15 cents. Yet metals may become higher-priced as rich ores get worked out.

Father Time will be the referee!

Many a Slip 'Twixt F.O.B. and "Del"

For years we "covered the water front" where we followed the news of export-import business in steel and metals. Many a 4 o'clock tea we drank with our English friends in New York, served by men in white coats. Many a weird tale we heard — of shipping worn out files and horseshoes to China from which the natives fashioned razors and other cutting elements. Horseshoes that had pounded over cobblestones were said to be metallurgically the best.

In those days we heard many statements on the superiority of American metal goods f.o.b. American mills, but marked inferiority, delivered Rio de Janeiro or Timbuktu. Americans were careless in their packaging, and wire rods arrived all bent and nails were bursting out of kegs. Not so with the Germans. That was in 1920

Shortly after the fall of France in 1940 the Government took possession of stocks of steel that had been packed for shipment to France. But much of it, lying on a New York dock, was usable only as scrap.

Since then a manual has been prepared, it has been announced by WPB, giving definite specifications for packaging export steel shipments. The work has been done by the American Iron & Steel Institute, with the cooperation of WPB, other Government agencies and representatives of foreign purchasing missions.

The packing and marking specifications set up by the manual are designed to protect steel from the elements and assure that transportation from ports of destination will be practicable. Often packages are too large to be lifted by dock equipment.

Purchasing missions from the following countries were consulted in the manual's preparation: Belgian Congo, Great Britain, China, Fighting France, Iceland, Netherlands, Russia and Turkey.

This all should be very useful after the war when there will be a merry scramble for overseas trade.

Gold Plated on Steel Shells?

To what industrial uses can gold be put? That is the question we asked our readers last February on behalf of the Board of Economic Warfare, which is making a survey. One reader's response suggested gold plating steel shell cases so that they will not stick in the guns. He is Olaf J. Arness, Chicago.

He writes, in part, as follows: "Where I work we are making steel shells. Rather many failures to eject come from the proving tests. These shells are sprayed with some clear stuff — looks like lacquer or some type of varnish. A high-speed gun firing many rounds per minute gets pretty hot.

"To my way of thinking, this sprayed-on stuff can stick plenty under the terrific explosion power plus the gripping of any sprayed on materials — even baked under ideal conditions. Wouldn't it be very interesting to electroplate with gold, which I am very certain would never stick on the highly polished breech chamber walls? With the highly work-hardened shell case, which is very smooth, very little plating would be necessary. At any time the gold could be reclaimed."

Gold: Exception to Production Rule

Production records in reverse have surrounded gold. Output from domestic mines in February, 1943, was 111,818 fine oz., a decrease of 61 per cent from February, 1942, and a drop of 16 per cent from January, 1943.

All of which is probably good news, under the circumstances.

The sharp declines are largely because most gold mines have either closed, or are in the process of closing.

There is still a substantial output of by-product gold from copper, lead and zinc-lead ores, increasing at some mines because of the larger production of base metals.

Our Two Great Metal Societies

The new president of the American Institute of Mining and Metallurgical Engineers has courageously brought into the open the "competitive" situation involving the Metals Divisions of the A.I.M.E. on one hand and the American Society for Metals on the other. He has asked A.I.M.E. men to consider means of effectively meeting this competition from the A.S.M.

Like many members of the A.I.M.E., we are personally also members of the A.S.M. and have no preferential loyalty to either society. But the competition *is* unfortunate, and without taking any sides in the matter, we do believe that it offers a potential threat to the continuing progress of the metallurgical arts and sciences. Let's examine for a moment the functions and fields of the two great American metal societies serving those arts and sciences.

In its own sphere of activity—the heat treatment, forging, welding, properties and uses of alloys—the A.S.M. has grown with phenomenal speed and has achieved a virtually unchallengeable position of power and leadership, through perfectly legitimate organizational tactics and very popular membership services. The A.S.M. now has over 50 active local chapters, and these—with all their members—form a well-integrated group having a strong common interest in the one general field just mentioned—the metallurgical aspects of treating and fabricating metals.

Similarly, in *its* province—the technical problems of smelting, melting, refining and mill-processing of iron, steel and non-ferrous metals—the A.I.M.E.'s influence heavily predominates. In these fields it has fostered and developed such immensely helpful groups as the Open-Hearth Committee, the Blast Furnace and Raw Materials Committee, the Non-ferrous Metallurgy Committees and others. The A.I.M.E.'s Open-Hearth Conference held last month, for example, strikingly demonstrates what the Institute can accomplish when it really starts to roll—and *in the field that constitutes its natural franchise.*

Clearly, the A.S.M. is the society of metal fabrication and treatment; just as clearly the A.I.M.E. is the society of metal production and refining. Instead of fighting each other, therefore, *why do not the two societies come to an informal agreement whereby the Metals Divisions of A.I.M.E. would embrace the arts and sciences of metal production and refining, and the A.S.M. would abandon its secondary interest in those fields and cover the technical problems of metal-working, treating and alloy properties?* In other words, the A.I.M.E. would relinquish the physical metallurgy field to the A.S.M. and the A.S.M. would, in turn, hand over its "production of metals" coverage.

Within these respective and well-defined provinces a great job can yet be done by the covering society in each case. The A.S.M. can still add to its roster thousands of members eager for metallurgical help on just metal working and treating. In its turn the A.I.M.E. can grow a hundred per cent in its steel-making membership alone. But the expansion of

each group should be through *intensification* of their respective natural fields outlined above and not through further encroachment by either on the field of the other.

There now exists a relatively small area of duplication and conflict. Instead of adding to this overlap we should all strive to *eliminate* it. And then—to use Gillett's graphic phrase—let each group concentrate on its own supremacy sphere!

—F. P. P.

Placing Orders for Steel

Attention is called, by those who are in a position to know, to a trend in ordering steel by war consumers which is a distinct departure from pre-war and earlier custom. Previously it was the broad practice to specify precise chemical composition of the material desired rather than to stipulate the mechanical properties. Now it is reported that many customers in placing an order no longer define the chemical content but specify the particular strength or hardness necessary for the job in hand. This custom places the burden on the steelmaker of selecting the steel that will meet the customer's needs.

This practice is said to be working out so favorably that it may become permanent in the post-war world. Its development has come about quite naturally. One of the main causes has been the shortages of certain alloying elements—the steel producer could not always meet a chemical specification because of inability to secure certain alloys, but if left to his own ingenuity and to his knowledge of metallurgy, he could fill the bill.

Another factor in the success of this trend has been and is the experience of the steel foundry producers of cast armor plate. Most of this product since the war started has not been made to chemical specifications—the customer merely has stipulated certain physical properties desired, and many thousand tons have been thus successfully produced.

Why should not this trend persist after the war? It has many advantages. So long as a satisfactory product is made, the steelmaker has a greater freedom of choice—he is not bound down to a fixed formula as to composition. And it will mean the elimination of a surplus of specifications. The filling of orders with a simpler alloy steel, even a carbon steel, suitably heat treated, is likely to become more general.

—E. F. C.

Grinding and Fatigue Life

In a very interesting and thought-provoking paper presented before the Detroit Chapter of the A.S.M. at its November, 1942, meeting and recently reprinted in some technical magazines (see *Metal Progress,* Vol. 43, No. 2, p. 209, and *Automotive and Aviation Industries,* Vol. 88, No. 3, p. 28), J. O. Almen discussed the influence of the surface finishing operations on the fatigue life of a hardened and ground steel part. The conclusions reached by the author are worthy of consideration.

These conclusions, relating to the effect of grinding hardened machine parts, are briefly summarized: ". . . the grinding operations may introduce high surface tension stresses and thus promote fatigue failures. More harm than good often results from the grinding of machine parts."

The evidence presented by the author fails to support his too general conclusions. Unfortunately, his statements are liable to be interpreted literally by persons unfamiliar with high production grinding techniques (for there are many "green" men and women among the technical staffs as well as in the factories of our armament industries). It is our suggestion that these conclusions should not be so interpreted. They apply only in the case of highly stressed parts, and more specifically, to such parts as are subject to reversing stresses of large magnitude. It would have been more helpful if the author had not drawn such broad conclusions from observations of, and test results dealing with, a specialized type of ground part.

It should be remembered that the type of grinding operations referred to in this paper are precision finishing operations. As is common with all precision processes, there are two important factors that must be controlled if the engineer is to be able to specify (and to *get*) accurate, satisfactory and consistent results. These are (1), the proper physical

(Editorial continued on page 984)

Incandescent bursts of fire followed as water from hose streams came in contact with hot magnesium scrap during a fire in a scrap metal storage shed at a Connecticut plant. (Courtesy: Factory Mutual Fire Insurance Co.)

Preventing and Extinguishing

— A Survey

by HAROLD A. KNIGHT
Associate Editor

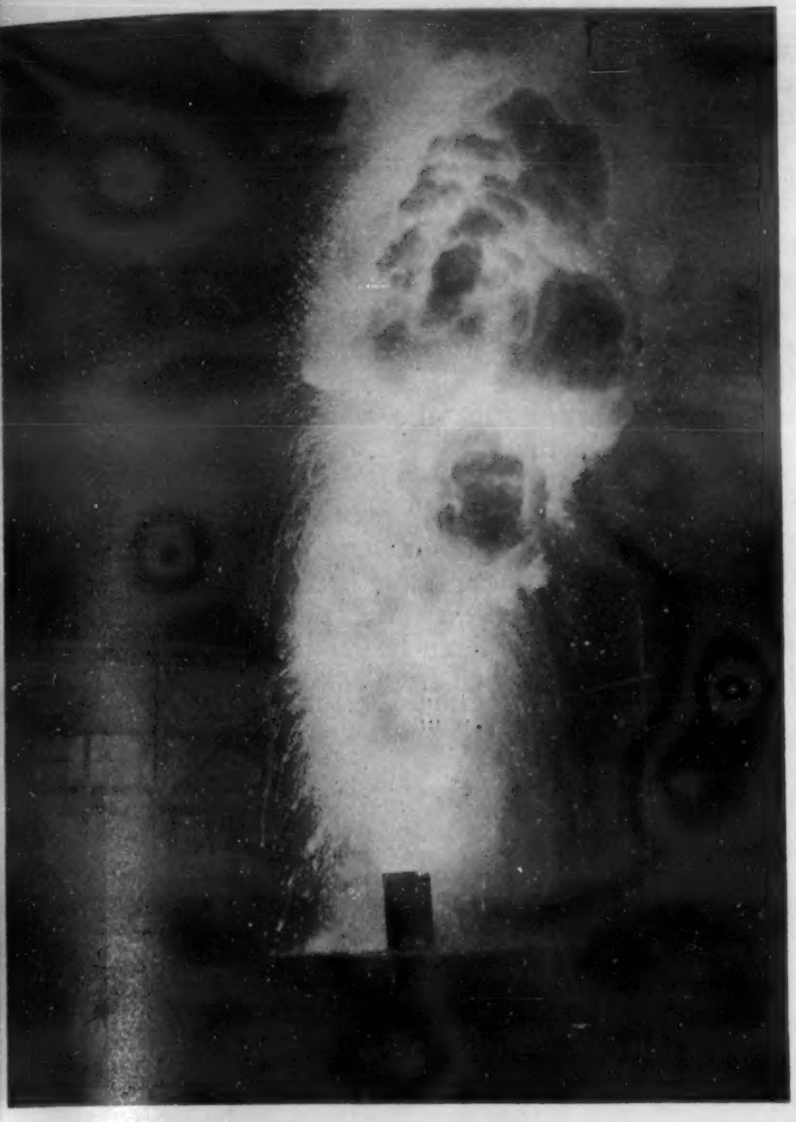
The "magnesium fire hazard" is something for which engineers must bear the greatest respect, particularly in these days when so much magnesium is being processed. With full knowledge of the causes and habits of magnesium fires and of available prevention and extinguishing methods, however, this respect need never degenerate into fear and an avoidance of this useful material because of its flammability in finely-divided form. To accumulate helpful information of this type, Mr. Knight made a comprehensive survey of Government bureaus, fire-insurance bodies, magnesium producers, magnesium consumers and manufacturers of prevention and extinguishing equipment, and out of the mass of data collected he has distilled the essence of magnesium fire-control presented in this article. We particularly recommend to engineers and shop supervisors handling magnesium the careful study and posting of the "check lists" for fire prevention appearing in the form of boxes throughout the article.

—The Editors.

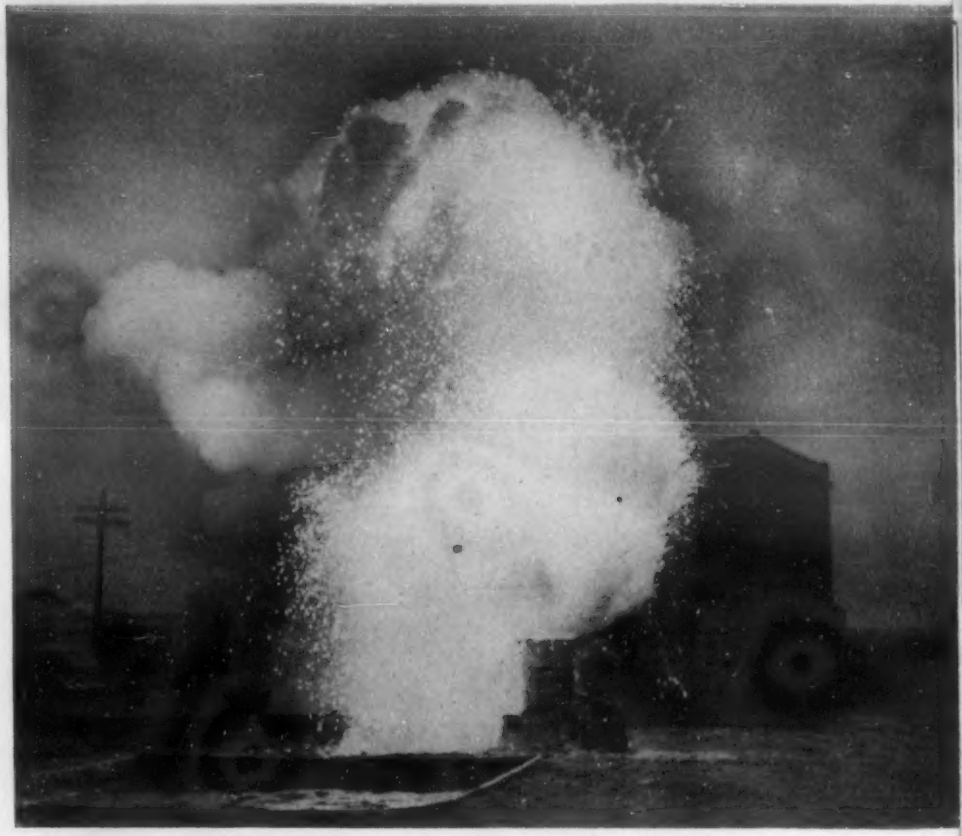
ON SEPTEMBER 14, 1942 at Sandusky, Ohio, there was an estimated fire loss of $55,000 because open drums of magnesium turning at a reclamation plant were stored in an unsprinklered, corrugated-iron wood-frame building. Employees, noticing a warm spot, started to remove the drum when fire flashed over the open drums of oil-soaked chips. The building and contents were destroyed.

From 1917 to 1939 there were at least 45 explosions of aluminum, magnesium or zinc powder, with losses serious enough to be recorded in the newspapers. There were 44 lives lost, 58 injured, and with property loss of over $1,700,000.

A 50-gallon drum of wet magnesium chips burning during a test at Factory Mutual Testing Station.



Violent combustion of magnesium scrap in simulated melting furnace during test at Factory Mutual Testing Station.



Magnesium Fires

At Hounslow, England, a disastrous fire occurred February 14, 1940, in a 15-ton pile of magnesium filings and cuttings, lasting over 48 hrs. and injuring seriously 14 firemen by explosions. In the building were 200 tons of aluminum scrap. Twenty hose streams were played on the burning metal. The firemen did not realize that oxygen from the water caused the explosions.

In a metallurgical plant in Little Falls, N. J., in June, 1939, magnesium alloy castings in an electrically-heated circulating atmosphere heat-treating furnace ignited. No one knew how to handle the fire and nothing was done for a while. Finally somebody recalled that there was a fire department in the village. It was called and, in the language of a printed report: "It is understood that the furnace doors were opened and a hose stream thrown on the burning castings within the oven. Details are lacking from this point on (things happened too fast, apparently), but the loss is understood to have been $50,000, although this appears rather high."

These few examples and statistics are enough to indicate the hazard represented by insufficient knowledge of the prevention and extinguishing of magnesium fires.

Just as physic should not be given to cure a stomach ache of the patient who still has an appendix, so should water not be used in a magnesium fire unless the fire "doctor" prescribes it—and that would probably be only for an incendiary bomb. This is the one cardinal rule to remember when faced with a magnesium fire.

Standard Rules and Materials

Standard rules and materials for fighting magnesium fires have been worked out by the leading magnesium companies. Industry in general, however, has not been educated to the point where they can weed out the bad practices from the good ones and so some confusion is inevitable.

Even the public is confused on technique with incendiary bombs. First, it was merely a water spray, but then the orders were to use a solid stream, presumably on the theory that if you whip a horse that is running away he will run all the faster, the sooner to exhaust himself.

Here are a few instances of the confusion and contradictions among the experts. Bureau of Mines tests found hard coal-tar pitch, in granulated or flake form, effective in most types of magnesium fires. This pitch is the residue from the distillation of coal tar. It softens rapidly and forms an effective seal that excludes the air. Dr. R. R. Sayres, director of the Bureau of Mines, reported to the Secretary of the Interior that the pitch method "is regarded as superior to the use of sand and water or prepared

Special dry-powder extinguishing compound is used successfully to control a fire from burning magnesium chips at Factory Mutual Testing Station.

compounds, none of which is believed entirely successful in putting out a magnesium fire." A practical plant expert wrote us: "We feel that hard pitch, besides being one of the cheapest extinguishers for magnesium fires, is also the best."

Yet, R. I. Thrune, safety engineer, Dowmetal Div., Dow Chemical Co., states: "We have done a great deal of work with coal-tar pitch as an extinguisher and find it efficient if the quantity of magnesium in the fire is not greater than 6 to 10 lbs. If the quantity of burning magnesium is greater, or if the fire has burned long enough to generate a great deal of heat, then the pitch itself is combustible and additional fires result from the burning pitch."

The expert in favor of pitch answers this by saying: "It is impossible to avoid some burning of the pitch and consequently the formation of some black smoke, particularly when the pitch is first applied. The amount of smoking can be limited, however, to a point where it is not objectionable by the rapid application of relatively large quantities of the pitch."

Mr. Thrune states further: "It is our honest opinion that G-1 powder (made by the Pyrene Mfg. Co., 560 Belmont Ave., Newark, N. J.) is the best all-round extinguisher for magnesium industrial fires inasmuch as it can be used on fires of almost any size."

As to another contradiction. We saw a demonstration of an extinguishing agent with a thermite incendiary bomb, the medium having been chiefly graphite. One demonstration was made on a thick steel plate; another on a wooden plank. After the fire a considerable hole appeared in the steel plate —the fire had burned completely through. The wooden plank, however, was only charred and the demonstrator explained how the charcoal had "sort of" insulated the plank against further burning. Yet all the experts speak in favor of the steel plate every time.

Mr. Thrune explains that where the fire burned through the steel, it was that of a steel-cased thermite bomb. "However, with a magnesium incendiary bomb the temperatures are lower." To which we would reply: "But the usual incendiary bomb starts off with thermite as a primer and ends with magnesium—in other words, the so-called magnesium bomb contains thermite."

Continuing with the contradictions, a booklet on "Magnesium and Its Alloys," published by National Fire Protection Assn., Boston, states: "Use of pitch around machines is questionable because of difficulty of cleaning up." However, the Bureau of Mines states: "After the fire it can be removed easily as a shell or peeled or chipped from solid surfaces."

Safeguarding in Heat-Treating

Design furnaces to prevent overheating of the alloy by radiation from electric heating elements or brickword at a temperature higher than the atmosphere inside the furnace.

Remember that massive pieces of magnesium will not ignite readily, but thin projections or fine material in a casting are hazardous, as burning of these smaller pieces may communicate to the main body.

Maintain at atmosphere of 1 per cent sulphur dioxide in the furnace which tends to prevent ignition. In case of fire it will extinguish burning molten magnesium at the bottom, but not the unmolten castings. Moreover about 25 per cent of the charge can be ultimately recovered as scrap.

Keep furnaces as airtight as possible. Standard furnaces should be especially treated to make them airtight.

Remember, heat treating temperatures ordinarily are from 730 to 789 deg. F. At below that range magnesium alloy castings may be held at long periods. Ignition has been reported at over 800 deg.

The furnace should be kept clean and free of scale.

Before placing castings in furnaces be sure they are free and clean from grinding dust or sawings.

Don't mix castings requiring low heat treatment with those needing high.

Three Approved Extinguishers

Besides pitch, which is approved by the Bureau of Mines for small fires, there are three dry compounds which have official approval as magnesium extinguishers: DuMag powder, in 45-lb. pails, made by Dugas Engineering Corp., Marinette, Wis., approved by Factory Mutual Laboratories and Underwriters' Laboratories, Inc.; G-1 fire extinguishing powder, graphite and complex chemicals, in 40-lb. pails and 350-lb. drums, approved by both Factory Mutual and Underwriters' Laboratories, and Carey MX granules, made by Philip Carey Mfg. Co., Lockland, Cincinnati, and approved by Underwriters' Laboratories,

Inc. Naturally the proprietors of these products regard their exact ingredients and proportions as trade secrets. All they say about DuMag, for instance, is that it is a salt and an asphaltic substance.

To quote Mr. Thrune of Dow again: "G-1 powder, cast iron borings, and graphite powder can be used effectively on fires of almost any size, but G-1 powder is our preference." Yet an expert in a magnesium plant says: "G-1, soft coal sand, soft-coal-graphite and Mexican graphite No. 30 are the least efficient." But later he says: "For fires on or around machine tools it would probably be best to use G-1 powder, Mexican graphite No. 30, or cast iron borings, since these extinguishers can be cleaned up easily and do not injure delicate moving parts or bearings.

Other materials which have been used with varying degrees of success have been: Sand, borax, Portland cement, powdered limestone, talc, powdered shale, brass turnings, shredded asbestos, ashes, crushed hard coal, sodium and potassium chloride mixes, and salt. Ford Motor Co., for instance, uses sand, but this is good only for small fires, since with large fires the air seeps through, the air's oxygen aggravates the flames and there is a chemical action between the silica and magnesium. Moreover if the fire is on machinery one can imagine what sand does to the gears, etc. "Dry Portland cement has been found effective in tests by the Factory Mutual Laboratories," states the booklet, "Magnesium and Its Alloys." Liquid extinguishers such as 600 W oil and diethylene glycol are satisfactory on very small fires.

Ideal Qualifications

The ideal extinguishing agent is non-abrasive, non-corrosive, non-flammable, non-toxic and capable for big fires, inert to burning magnesium at all temperatures, is a good conductor of heat, must be easy to store and supply, must be non-conductive to electricity, and should not absorb moisture from the air.

Ideal places for the fires are on floors of iron, steel or hard-burned paving brick. On such sites one throws extinguisher as gently as possible (so as not to fan the flames or stir up the mass) and in sufficient quantity. This curbs and confines the flames, shutting out air and eventually leaving a residue of unburned magnesium.

If the fire is on a flammable floor, add the extinguisher to the top of the flames, as before, then make a pile of the extinguisher alongside the fire, perhaps 2 in. thick, and hoe the burning mass upon it, adding more extinguisher to the top, as necessary

As to cement floors, these are never to be trusted. A wet floor, of course, contributes oxygen from the moisture and causes explosions. A green (newly-laid) floor does the same. Moreover the old cement floor is to be looked upon with suspicion for the water of crystallization in the calcium, sodium and other salts often causes a bit of popping, perhaps scattering the fire. The author has witnessed such explosions from a fire in only 1 lb. of magnesium.

"Physical Properties" of a Magnesium Fire

Since you and I, reader, are sticklers for real facts, let's see just what this magnesium gremlin is. Magnesium in the form of ribbon, 0.2 in. by 3.0 mm. is ignited at a temperature of 940 deg. F. Factory Mutual Laboratories has stated that where an entire piece of metal can be raised to 930 deg. F. ignition will take place. J. A. Gann points out that ignition temperatures will drop rapidly as particle size decreases. Metallic or electric sparks have produced ignitions of magnesium powder and the dust ignites readily in the Clement-Frazer apparatus with the coil at 1652 to 2192 deg. F.

In Foundries and Die-Casting Plants

Locate in non-combustible fire-resisting buildings and on first floors. Have ceilings high so that burning vapors will not damage ceilings nor "mushroom" and spread the fire. If necessary, replace roof planks with non-combustible material, or at least sheath the underside with asbestos millboard, or with cement plaster.

Automatic sprinklers are not advisable.

Floors around melting units should be hard-burned or vitreous paving block.

Melting pots or furnaces should be in a pit; at least a curb should be provided on the floor to prevent spread of molten metal in case of pot failure. Inspect and hammer furnace pots regularly to avoid using beyond their safe life.

Furnace settings must be cleaned often enough to keep them free from iron scale, which might cause a thermit reaction with molten magnesium.

Use a flux on the surface of molten metal in melting pots. In ladling, use a mixture of sulphur and boric acid to prevent ignition, a mixture which can extinguish small fires caused in spattering of the molten metal when pouring into molds.

Preventing Fires in Grinding

A dust collection system should be used which utilizes a water spray nozzle to knock down the dust, to be carried away as a sludge.

Dust particles should be wet by a spray as close to the grinding wheel as possible. Explosions are liable in dry ducts.

Good ventilation is needed to remove the hydrogen which is formed.

Sludge should be collected in drums and frequently mixed with 4 or 5 parts by weight of sand or dirt and buried in a dump. Do not let sludge stand in half-wet condition as temperature might rise to the ignition point.

Do not attempt to reclaim magnesium dust.

Do not use grinding wheels which work on magnesium and its alloys for other metals.

One method of handling dust, sweepings and sawdust is by wetting with cheap high-flash-point mineral oil, which can then be disposed of by burning on a dump or mixing with sand and burying.

It is well to use booths and dust collectors of special design, now commercially available.

Extinguishing a fire from magnesium chips on a machine tool. The extinguisher used is G-1. (Courtesy: Pyrene Mfg. Co.)

The violent reaction of burning magnesium when water is applied. (Courtesy: Factory Mutual Testing Station)

Underwriters' Laboratories, Inc., write us that in their tests maximum combustion temperatures of burning magnesium alloys in chip, sawdust and turnings forms, as measured by thermocouples placed in the glowing mass 1 in. beneath the surface of the glowing cone-shaped piles of these materials, was approximately 2220 deg. F. Factory Mutual finds that magnesium dust, upon exploding, develops a pressure of 68 lbs. per sq. in. by comparison with 37 lbs. for aluminum powder and 32 lbs. for cornstarch.

Although magnesium is not attacked by water at room temperature, it is slowly decomposed by water at 212 deg. F. with the formation of hydrogen. Naturally, this hydrogen burns along with the magnesium.

There is an instance where sparks from a grinding wheel ignited magnesium dust and caused an explosion that killed three men and injured several others. Violent explosions of magnesium powder have taken place in atmospheres where oxygen has been reduced as low as 12 per cent. All equipment used around finely powdered magnesium should be grounded to prevent accumulation of charges of static electricity. This grounding is not necessary for ordinary work with magnesium.

Comparative Extinguisher Tests

An interesting series of tests was conducted with Dowmetal chips, first with piles containing 4.5 lbs., and second, with 14 lbs., using various extinguishers, the tests having been conducted by R. I. Thrune of the Dow Chemical Co., Midland, Mich., and G. B. James of the Western Factory Insurance Assn., 175 W. Jackson Boulevard, Chicago. All tests were made on metal pans, 3 x 3 in., under a fan-ventilated hood, the purpose being to determine the best extinguishing medium.

Let it be said by the author, however, that only one of the three proprietary compounds approved by Factory Mutual or Underwriters' Laboratories figured in the tests, others having been invented since.

The chips were fairly coarse and were piled about 17½ in. in diam. and 2½ in. deep. A gas torch applied in circular motion started each fire. The mass was stirred with a poker. When burning freely the gas was shut off and the air from the torch was played on the fire to secure more intense burning. The fire burned for 1½ min. before any extinguisher was applied.

The following are highlights of tests with the 4½-lb. piles. G-1 powder was first used, which consists principally of powdered graphite with a small percentage of liquid plasticizer. When a thin layer was applied, a slight smoky flame appeared, formed by the burning of the organic material in the mixture. These fumes seemed to have a smothering effect. More G-1 was added until 5.2 lbs. of powder, ½ in. deep, was used. When the crust was broken open with a poker 30 sec. after the last G-1 was applied, no flames or glowing spots were evident in the mass.

In the second test dry sand was applied, 12 lbs. in all. Thirty seconds after the flaming of the magnesium ceased, the mass was loosened with the poker and many glowing spots were uncovered which burst into flame again.

When sodium bicarbonate was used, placed ¾ in. thick over the burning magnesium, radiated heat was increased, gases kept breaking through and no crust

Preventing Fires in Machining

"Good housekeeping" is the first rule in any primer.

No more than 10 lbs. of chips or turinngs should be allowed to accumulate around any machine before cleaning and removal. No turnings should be left in these areas overnight.

Turnings should preferably be stored in a noncombustible building in tightly covered metal containers separated from other combustible material.

Storage in a combustible building protected by automatic sprinklers is acceptable if containers are tight against the entrance of water.

Large accumulations of turnings in storage should be avoided. Material should be returned to the recovery plant and melted down into solid ingot promptly.

Do not remove automatic sprinkler systems. They wet down surrounding areas, preventing spread of magnesium fires.

Keep cutting tools sharp, then there will be less friction and fewer fires.

formed. G-1 powder was used to extinguish it.

Apparently dry salt was more successful. A slight crust formed and when this was broken open a few glowing spots broke into flame for a short time and subsided.

Powdered red talc appeared successful in the early stages but, after the 30-sec. lapse, the pile was stirred slightly and broke into fire readily, with G-1 finally applied.

Powdered asbestos showed the same insulating effect as talc. Decomposition gas continued to break through a layer of asbestos 1 in. thick. When the mass was opened after 30 sec. a very hot fire broke out. Dry cast iron borings were put on 1/2 in. thick. No glowing spots of any consequence were found and the few small ones did not burst into flame.

Powdered graphite produced a few minor glowing spots but were extinguished easily as the mass was stirred with a poker. Because of the crusty metallic layer formed, unburned magnesium was found. With medium asbestos fiber 1 1/2 min., besides the standard 30 sec. was allowed for cooling but when the mass was stirred the entire body of metal was glowing and fire broke out readily, G-1 finally being applied.

In the second series of tests where 16 lbs. were used, only two tests were made. Of this 16 lbs., 2 lbs. were very thin Dowmetal shavings to help secure a very hot fire. In the first, dry salt was applied to a thickness of 3/4 in. After 1 1/2 min. the mass was opened and several glowing spots were found below the crust which broke into flames immediately and increased in size. Considerable additional salt finally extinguished it.

In the second test G-1 powder was applied 3/4 in. deep. After 1 1/2 min. the original smoke which had appeared from two spots had subsided. A heavy crust had formed which, when broken, showed a few small glowing spots, but no flame, the spots dying out completely.

Significance of the Tests

The sponsors of these tests summarized them as follows: G-1 shows results complying with six of the most important requirements of an extinguisher and in addition shows efficient smothering action owing to the vapors formed when the small amount of organic matter in the mix burns. Powdered graphite is less effective than G-1 as it is not as easy to apply because of free dust and hence explosion hazard. In G-1 this dust has been taken up by the organic material in the compound. Graphite does not show the smothering action of G-1. As to cast iron borings, unoxidized dry material seems satisfactory, but often partially oxidized or slightly moist may be encountered. The high density of borings may make application difficult, they tend to sink into molten magnesium. The other extinguishers failed to conform in three or four respects out of the six.

Conclusions, in the words of the sponsors, were: "G-1 powder, powdered graphite and dry unoxidized cast iron borings are the most successful means for extinguishing fires in magnesium alloys. Sand and talc are much less desirable. However, for small quantities of magnesium they may be used. Specifications for powdered graphite are: It must all pass 6 mesh screen, and about 33 1/3 per cent must pass a 200-mesh screen." The report is signed by H. G. Jordan, supt. of inspections, Western Factory Insurance Association, and is dated April 1, 1941, since which date probably other efficient compounds have been developed.

Fires in Heat-Treating

Magnesium fires in heat-treating furnaces are among the more prevalent. H. S. Hirst and A. B. Guise, both recognized authorities, state that fires in reasonably airtight furnaces have been extinguished by throwing a large quantity of waste soaked in high flash point oil on the floor of the furnace and sealing furnace openings. Inert products of the combustion of the oil smother the magnesium fire.

G-1 powder is recommended as an extinguisher. For a fire in a small heat-treating furnace the G-1 may be thrown upon the burning areas with a small shovel. Large installations may require that G-1 be pumped or sprayed in through the open door.

A fire may be indicated by the abnormal rise in temperature. Circulating fans and heating units should shut off automatically when the temperature trips the safety control. This should be done manually if the safety control has failed to work.

The operator with the G-1 pump should stand near, but not directly in front of, the furnace door to avoid the extreme heat. Testing the pump for certain operation, the door is opened and the nozzle is inserted between the work to get the powder where needed. All castings, or other work, should receive a layer of powder to quell any incipient fires.

Castings should be allowed to cool with the furnace door open, but a close watch must be kept to prevent re-ignition of the hot metal.

Fires in Grinding

Fires also occur in grinding magnesium alloys. E. T. Larsen, sales engineering department, Norton Co., writes in *Grits and Grinds*, December, 1942 issue: "Do not use water, or any liquid extinguisher. Smother the fire with an asbestos blanket; a large piece of clean, dry boiler plate; or a layer of dry, noncombustible material such as powdered graphite or rust-free cast iron borings. Dry sand or earth can be used on a small fire when recommended materials are not within reach. Never use dry soda, carbon tetrachloride, carbon dioxide gas or foaming type extinguishers. Factory and city fire departments should be emphatically cautioned by the management and be made familiar with the above precautions."

The principles, methods and materials used in putting out magnesium fires generally, as outlined previously in this article, also apply usually to fires in magnesium foundries. Charles G. Durfee, with the Pyrene Mfg. Co., has mentioned seeing buckets of

dry shredded asbestos at every foundry machine. "But the reaction is violent when the asbestos is brought up to the reacting temperature," stated Mr. Durfee. "Apparently not only does the water of crystallization of the asbestos add fuel to the fire, but there is a very definite silica reaction which proceeds most energetically.

"Oddly enough, sand, too, will react with burning magnesium. Even if you dry the sand carefully in an oven so that it is absolutely free of moisture, you will get a reaction — nowhere near as strong a reaction as with asbestos, but, still, a formation of magnesium silicates.

"If you see a pile of burning magnesium chips, study the surface," continues Mr. Durfee. "You will see the white magnesium oxide formation on the surface and with that you will also see streaks of yellow material, which prove to be magnesium nitride. If an attempt is made to put a snuffer over a magnesium fire, the magnesium will react with all the oxygen under the snuffer and then will keep right on reacting with the nitrogen so, unless you have a snuffer that will hold a pure vacuum, you are going to have a pretty hard time trying to snuff out a magnesium fire."

Final Impressions

The chief metallurgist of a magnesium company concluded, after a long dissertation on magnesium fires: "There are certain types of magnesium fires for which there is no known method of control. It has been general experience that when a warehouse full of magnesium turnings, sawdust or powder burns, nothing much can be done except to keep the fire from spreading to adjoining buildings."

Doubtless the reader here near the end of this article still has no clean cut ideas of what is positively the best extinguisher and best technique. The experts themselves still differ and apparently each worker with magnesium must form his own conclusions. The Ford Motor Co., for instance, still uses sand, according to a letter received from them shortly before going to press.

The author of this article leans heavily towards the recommendations of R. I. Thrune, quoted frequently in this article. We visited him, watched him work on fires with many extinguishers. We were convinced of his sincerity and apparently thorough study of the subject. Moreover we feel that Dow should understand magnesium, if anybody does. G-1 powder therefore stands high in our estimation.

Dust Collector Manufacturers

Industrial Sheet Metal Works, Detroit
Claude B. Schneible Co., Chicago
Schmieg Sheet Metal Works, Detroit
B. F. Sturtevant Co., Boston
Pangborn Corp., Hagerstown, Md.
W. W. Sly Mfg. Co., Cleveland
Kirk & Blum Mfg. Co., Cincinnati
American Foundry Equipment Co., Mishawaka, Ind.
R. C. Mahon Co., Detroit
American Blower Corp., Detroit
American Air Filter Co., Louisville, Ky.

Extinguishing Compounds

G-1 powder. Contains graphite and "complex materials." Made by Pyrene Mfg. Co., 560 Belmont Ave., Newark, N. J. Approved by Factory Mutual Laboratories and Underwriters' Laboratories, Inc. Sold in 40-lb. pails and 350 lb. drums.

DuMag. Is a salt, with an asphaltic material. Made by Dugas Engineering Corp., Marinette, Wis. Approved by F. M. L. and U. L. Sold in 45-lb. pails.

Carey MX granules. Made of "non-critical materials." Made by Philip Carey Mfg. Co., Lockland, Cincinnati. Approved by U. L.

Hard coal-tar pitch, in granulated or flake form. Approved by U. S. Bureau of Mines. (At least 10 prominent marketers.)

Magout powder. A non-absorbent, finely pulverized dry powder. Pulmosan Safety Equipment Corp., 176 Johnson St., Brooklyn, N. Y. Available in bulk or in handy cardboard containers.

Speedi-out. Hard coal tar pitch, that is non-abrasive, non-corrosive and non-toxic. Waverly Petroleum Products Co., Philadelphia. Endorsed by U. S. Bureau of Mines.

Bomb-Quench. Made by O. H. Adams Co., 2018 E. Thomas Ave., Milwaukee. Apparently designed chiefly for incendiary bombs.

National DX powder. (Developed in Great Britain, but not yet readily obtainable in U. S.)

Spargo. Salt and a phosphate. Made by Cunningham Chemical Laboratories, Inc., 113 E. 138 St., New York. Blue label, for dry magnesium and Red label, for oily magnesium. On the market only a few months.

Pump tank fire extinguisher. (For incendiary bombs only.) Made by American La France Foamite Corp., Elmira, N. Y.

G.-1 Powder Pump. Made and sold by St. Regis Paper Co., Otsego, N. Y. Will throw stream of powder 30 feet, suitable for large fires.

No-Inferno. Made by subsidiary of Aluminum Co. of America at East St. Louis, Ill. and sold by C. P. Hall Co., 1340 East Sixth St., Los Angeles. Is chemical powder extinguisher for magnesium and Thermit fires.

Chokeout, No. 1 and 4. Made by O. Hommel Co., 209 Fourth Ave., Pittsburgh. No. 1 in granulated form, from 6 to 35 mesh; No. 4, extremely fine powder, good where fire is on perpendicular surface since it will stick to that surface.

Mexican graphite, Nos. 160 and 30. Made by U. S. Graphite Co., Saginaw, Mich., the numbers signifying the mesh.

Sulphur Dioxide. Ansul Chemical Co., Marinette, Wis., and others. This produces atmospheres in heat treating furnaces that tend (among other things) to prevent fires. In case of fire it will extinguish burning molten magnesium.

Cobalt Electrolytically Refined

by Carl S. Oldach and Ralph Landau

Massachusetts Institute of Technology, Present Addresses: E. I. Du Pont de Nemours & Co., Inc., Wilmington, Del. and The M. W. Kellogg Co., New York, Respectively.

Cobalt, an important ingredient of many alloys essential to metal-working, electrical design and communications, is sometimes required of a purity higher than the 98 per cent or so commercially available. This article describes a simple, practical method of electrolytically refining cobalt to produce a 99.76 per cent metal. The method should be applicable to either large- or small-scale operations.—The Editors.

COBALT METAL IS AVAILABLE commercially in this country in the form of rondelles (small cylinders about ½ in. by ½ in.) which contain about 98.4 per cent Co. A typical analysis of material used by the authors is as follows:

	Per Cent
Cobalt	98.4-98.7
Nickel	0.18
Iron	0.19
Calcium oxide (CaO)	0.22
Sulphur	0.02
Manganese	0.06
Carbon	0.08
Silica	0.08
Unknown	Remainder

For many purposes it is desirable to have metal of higher purity than this. In connection with some work on the properties of alloys, an improved method was developed for electrolytically refining these rondelles. The electrolytically refined metal analyzed:

	Per Cent
Cobalt	99.76
Nickel	0.005
Iron	0.10

The electroplated cobalt had about 0.28 per cent oxide on the surface which was removed by heating at a red heat in hydrogen. The analysis given is on an oxide-free basis.

Although the conditions described here refer to small scale laboratory production, it is feasible to utilize the method for preparing pure cobalt on a larger scale. At the current efficiencies obtained the cost would not be high and further improvement is undoubtedly possible.

Operating Details

The cobalt was refined by making the rondelles anodes and plating out the purified cobalt on a *rotating* stainless steel cathode. The rotating cathode furnished uniform agitation at the electrode surface but the stirring action was gentle enough so that anode sludge was not thrown against the cathode. The cobalt rondelles were ground flat on one face (to provide good electrical contact) and placed closely together on a platinum sheet at the bottom of a large Pyrex jar, 8-½ in. x 10 in. The platinum was connected anodically and had an area of about 117 sq. cent. (18 sq. in.). The cathode (6 in. in diameter) was suspended above the anode and was rotated at 60-100 r.p.m. Electrical contact was made by a brush.

Satisfactory operating conditions were found to be approximately as follows:

Temperature	55 deg. C. (131°F.)
Speed of Rotation	60-100 r.p.m.
pH	4.5-5.0
Cathode current density	4.5 amps. per sq. decimeter
Bath Composition	
H_3BO_3	about 40 gms
$CoSO_4.7H_2O$	about 400-500 gms
NaCl	20 gms
Water	to make 1 liter

(the resulting solution is nearly saturated with boric acid and cobalt sulphate.)

Anode-cathode distance: 1½ in.

Total volume of solution used, about 2½ liters.

The general type of bath used has been described previously in the literature of electroplating[1].

The most significant variables were found to be pH, current density and speed of cathode rotation.

In more acid baths, hydrogen evolution becomes appreciable with accompanying decreased efficiency, and the plate is porous. In more alkaline baths, the plate has poor strength, flakes off, trees, and considerable cobalt hydroxide forms, both at the cathode, and as a sludge around the anode.

Higher current densities than those mentioned above may be employed, but the change in pH becomes so great that frequent adjustments are necessary and current efficiency decreases. At the rates of deposition used (about 8.3 gms per hr.) the pH was adjusted about every 3 hrs. by addition of sulphuric acid, since the bath becomes alkaline with time. Higher temperatures permit higher deposition rates, but evaporation becomes very large. At the temperature used (130°F.) it was necessary to feed water to the bath continuously by means of a self-operating siphon arrangement. Anode sludge, which always formed to some extent, was removed once a day to minimize side reactions.

Rotation of the cathode greatly improves the quality of the plate and makes high current densities possible with little loss in efficiency.

It is possible under the conditions here outlined to prepare coats up to 1/8 in. in thickness with comparatively little treeing and high efficiency. A coat of 1/32 in. thickness is smooth, dense, and coherent. These coats could be stripped off in large pieces with little trouble. Current efficiencies at the cathode were about 94 to 95 per cent (probably higher in the initial period) while the anode efficiencies ranged above 95 per cent.

Reference

[1] G. Soderberg, W. L. Pinner and E. M. Baker *Trans.* Electrochem. Soc., Vol. 80, 1941, pages 579-587.

Seam Welding with a Carbon Arc

by R. A. TOBLER

Atlas Heating & Ventilating Co.,
San Francisco, Cal.

Any practice that saves metal is of interest today. If in addition money and time are saved the practice is distinctly worth noting. Here, therefore, is a practical little item outlining a method and technique of seam welding light-gage steel, using the carbon arc instead of a metal arc, that is claimed to save all three —metal, time and money. This article was one of the award-winners in the $200,000 Industrial Award Programs sponsored by the James F. Lincoln Arc Welding Foundation, Cleveland. —The Editors.

By means of carbon arc fusion-welding, seam welding can be done at less cost and more speed and efficiency. This method consists in the fusing together of like metals, using flanged seams wherever possible to insure best results. With skilled handling the method has proved efficient also on square corners without seams.

Carbon arc seam welding can take the place of shielded arc welding; instead of applying or adding metal, one simply fuses the metal already there. It is adaptable to a wide variety of uses; for example, it is applicable to all light-gage steel welding, and is especially valuable in putting bottoms in buckets or boilers or any metal container. It has proven waterproof, air-proof, gas-tight, trouble-free. The method is fully one-third less costly, all factors considered, than shielded arc welding. One important factor at this time is that carbon arc fusion-welding saves metal as well as time and labor.

A Typical Application

While the illustration, for the sake of showing the process clearly, pictures the seam-fusing of two plates of metal on the same plane, the applicability of the method to the putting on of a bottom in a bucket or any metal container can readily be perceived.

A description of the particular job photographed is as follows: The two plates of metal were 1/16-in. thick, each about 10 in. long and 4 in. wide. The 1/4 in. flange was on the 10-in. side of each plate; the two flanges were placed together.

The metal plates are held together at first with pliers. (Of course if pieces were much larger than those photographed, clamps would be necessary.) For any but the smallest job, a water-cooled holder should be used. The ground is fastened on the steel table or plate; the lead to the work is fastened to the holder that holds the carbon.

A 1/4-in. diameter carbon arc rod is used. When placing the carbon in the holder, let it extend down about 3 in. Start with the machine in straight polarity, at 200 amps., 75 volts. Before commencing to weld, "tack" the two pieces together along the top of the flanges every 2 1/2 or 3 in. by touching with the arc. The photograph shows this "tacking" plainly. Then remove the pliers or clamps, and prop up the job on any block or brick or other device so that it stands at a 10 per cent angle or thereabouts, and then weld.

The purpose of the 10 per cent slope is to make the metal flow, and flow evenly—neither too fast nor too slowly. A little experience will show the angle or slope one can use best. Of course if this slope is too close to horizontal, the melted metal will back up and "bunch" in spots.

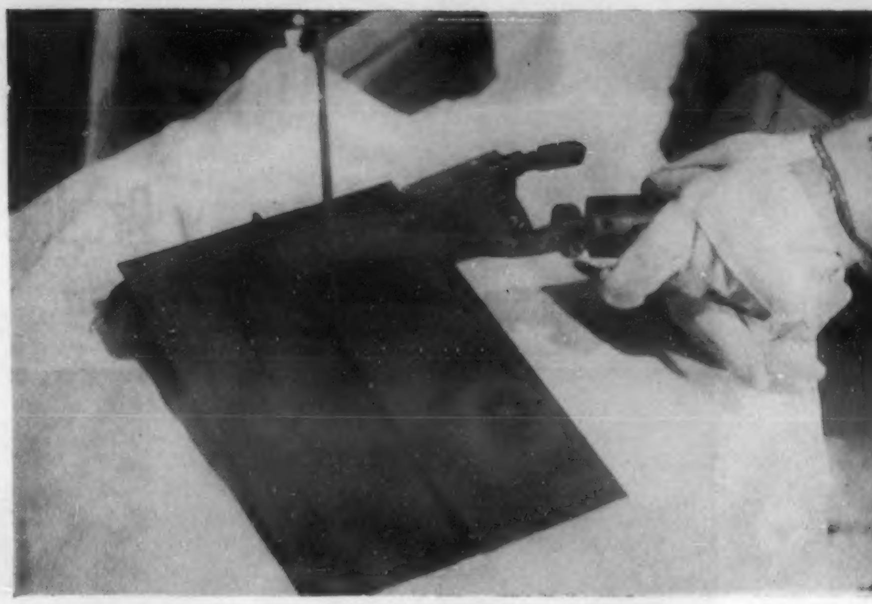
The puddle of molten metal will follow the tip of the arc, and the operator should keep just ahead of this puddle. If the puddle begins to get too large, the operator can control it quickly by (a) going faster, or (b) raising the arc just a trifle (just enough to lower the temperature and reduce the flow)—or he can do both. If the puddle tends to blend out, the work should be done more slowly.

After a little practice an operator will get the knack of adjusting the speed along with raising or lowering the arc; then one can increase the amperage up to 300 or 350 amps. and reach the maximum of speedy work. A skilled welder easily fuse-welds 250 ft. an hour if the metal is clean. This 250 ft. an hour represents the finished job.

If the metal is oily, the first time over burns the oil, brings out the "blow holes" as a result, and the welder will have to go over the job a second time to settle it.

General Advantages

This method is applicable to all steel, light-gage welding. The well-skilled welder can apply it to square corners without seam. The method works splendidly on all material of 14 to 20 gage inclusive; naturally the thicker the metal the more amperes and voltage will be needed to maintain proper speed and efficiency.



The seam fusing of two plates of metal on the same plane.

Proportionate cost saving is about as follows: Since Dec. 7, 1941, the stress on *metal*-economy has increased to such an unprecedented degree that any method that produces better results at even relatively little metal saving is surely worth considering. Seam-welding by means of fusing the metals together instead of by applying metal (carbon arc fusion-welding *vs.* shielded arc welding), in the author's plant is computed at fully one-third (33 1/3%) less costly.

This computation of a one-third saving takes in three factors: (a) The saving in metal; (b) the accomplishment of more work in less time; (c) and, last but by no means least, the fact that a fusion-welded seam has been proven trouble-free, complaint-free and dependable.

The estimated total annual gross cost savings accruing from the use of this method by the author's company is now impossible to determine, as the firm has gone into war work and such figures are no longer available.

For the industry in general, even the briefest survey of the number of uses for this method would show that such an estimated saving might run into the millions of dollars annually; the metal-container use alone extends the scope of this method to practically every major industry.

In addition to the increased service life efficiency, and general advantages accruing from this improved method, the benefits in public health, safety and convenience are self-evident, when the value of leak-proof, spoilage-proof food containers is considered.

Design of Sand Castings

for Quantity Production —Part 2

Fig. 8. Checking a magnesium aircraft landing wheel for accuracy. (Courtesy: Dow Chemical Co.)

by N. F. HINDLE

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In this second instalment of Mr. Hindle's detailed discussion of casting-design principles (Part I appeared in our April issue), pattern considerations and some general design rules are presented.

—The Editors

The first step in the production of any casting should be a sketch or drawing showing the general shape and approximate dimensions of the piece. Before the design takes its final form, however, the designer or engineer should consult a qualified foundryman, for the casting of metals is not an elementary process; it has its complications.

Selection of the producer should be given serious consideration. A choice should not be based on price alone. Items to be weighed should include assurances that the foundry has the proper equipment, sufficient capacity, skilled workmen, and capable personnel to exercise the necessary control over the various operations, materials and processes to insure the grade of product required, and a record of performance such

as to justify the expectation that satisfactory castings will result. Choice of the foundry may have little to do with design, but a good choice is likely to result in securing good castings.

Pattern Considerations

When a foundry has been selected and a design worked out, the foundryman or his engineers should be called into consultation before the pattern is made, as the type of pattern and size of the piece are important items which influence the final cost of the product. At this conference, there should be discussed such items as: (1) metal shrinkage, (2) how the part is to be molded, (3) location of parting line, (4) provision for gates (openings in the mold into which the metal is poured and introduced into the mold cavity), (5) location of risers (reservoirs of molten metal to compensate for decrease in volume as the metal solidifies), if any be needed, (6) number of castings to be produced in each mold, (7) feasibility of using match-plates, (8) accessibility of parts for cleaning, (9) location of machined surfaces, (10) dimensional limits which can be held, and many more items which contribute toward making the casting the best and most economical possible from a production standpoint. Many of these items have a pronounced influence upon cost and, as designing for quantity production is usually predicated upon lowest cost consistent with securing satisfactory castings, all factors affecting cost demand adequate consideration.

Since this article is limited to designing for quantity production by the sand casting process, the types of patterns which can be used are somewhat limited. If the order runs into the thousands for small castings and hundreds for large or medium sizes, to be made by machine molding, wood patterns are definitely out even though they may be made of hard wood. For large quantities of small castings, metal match-plates are recommended. For large quantities of medium and heavy castings, metal cope and drag patterns are recommended. Wood is not advocated because the sand abrades the pattern surfaces and produces inaccuracies in the casting. Also, the water in the sand is inclined to cause the pattern to warp, thus producing inaccuracies. A pattern is a tool for the foundryman and is merely a means to an end.

Shrinkage. All cast metals (except certain bismuth alloys, not commonly sand cast.—Editor) shrink when changing from the liquid to the solid state (liquid shrinkage) and in cooling from the solidification temperature to room temperature (solid shrinkage or contraction). Therefore, in pattern construction, allowance must be made for solid shrinkage or contraction by an amount added to the dimensions given in the casting drawing when producing the pattern. Shrinkage allowances on patterns vary with the metal in the casting and with the relation of one section to another in the same casting. For example, on a particular gray iron cylinder block casting, the shrinkage is 1/10 in. on the length, none on height and 1/6 in. on the width.

Engineers do well to be guided on shrinkage allowances by the advice of the foundryman and patternmaker. There are no fixed rules governing shrinkage, even with a given alloy, but the designer of the casting must consider shrinkage.

Risers. As all cast metals shrink in volume as they solidify, it is necessary to compensate in some way for this phenomenon. Risers, which hold reservoirs of molten metal, are used for this purpose. Such risers must be placed so that heavy sections and "hot spots" may be fed properly. Hot spots occur where, because some sections are thicker than others, solidification proceeds more slowly than in other thinner sections. Such hot spots are likely to contain shrinkage defects if not fed properly. Hot spots can be avoided if sections are uniform in thickness throughout the casting.

It is necessary that the casting should be designed, and the pattern so constructed, that the heavy sections and "hot spots" can be placed in the mold where they can be fed until the metal solidifies completely. Fig. 9 illustrates the right and wrong methods of designing to allow for shrinkage compensation. Increased cost of casting with increase in number of risers results from additional cost for removal of risers, additional molding time, additional pattern cost and decreased yield of metal as a casting, compared with total liquid metal poured into a mold.

Gating. In the production of patterns, the means whereby molten metal is introduced into the mold (the gate) should usually be included and permanently attached to the pattern, except in very large production castings not producible on molding machines.

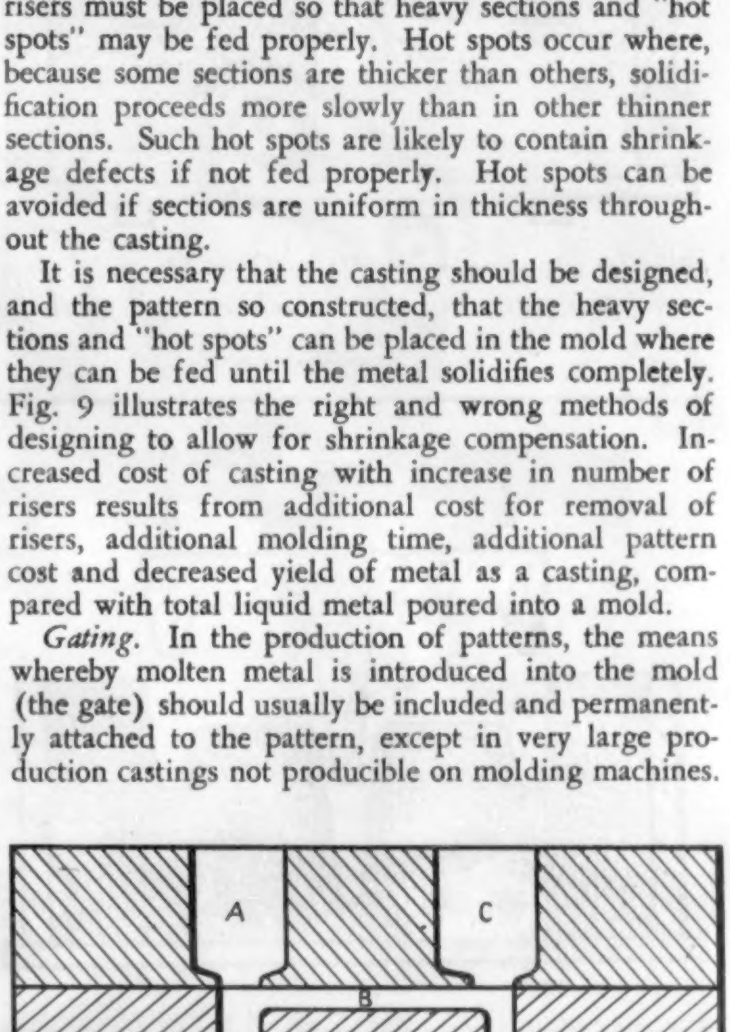

Fig. 9. How location of sections in relation to others influences the manner of solidification. The casting includes Sections A_1-A_2, B-B_1, and C_1-C_2. Risers are marked A and C. In cooling, A_2 is fed by the heavier section A_1, which, in turn, receives metal from riser A. Sections B and B_1, because of their lightness, cool almost instantaneously and require little feeding. Because heavy section C_2 is below the lighter section C_1, it has its supply of liquid metal shut off by the quicker freezing of section C_1. The provision of excess metal in riser C is ineffective because C_1 is lighter than C_2 and solidifies before the latter, this results in a defect at D. The remedy is to increase section C_1 to such a thickness that it will be as heavy as or heavier than section C_2.

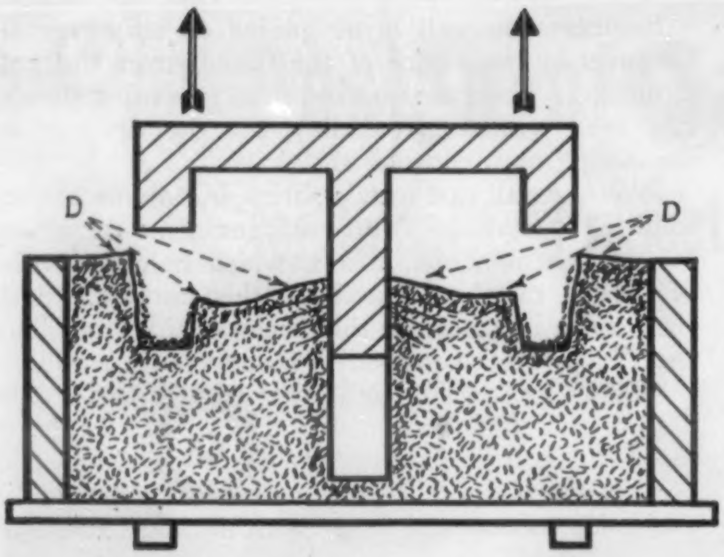

Fig. 10. Poor stripping from the mold results when using this pattern because no allowance is made for draft.

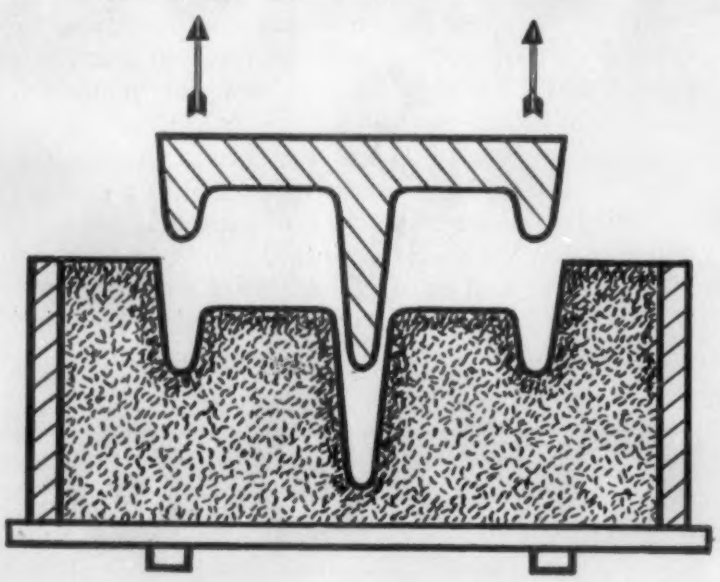

Fig. 11. This pattern has ample draft, hence it strips easily from the mold.

The location of gates, as well as of risers, should be the subject of a conference between the engineer, the foundryman and the patternmaker. No rules for location of gates can be given because of the wide variety of sizes and shapes of castings made. Each design must be considered separately.

Parting and Draft

Parting. In general, patterns with "straight" parting lines, that is, with parting in one plane, are more economical to produce than those with irregular partings. This is because special flask equipment and set-ups on machines are necessary to accommodate patterns or match-plates with irregular partings. Therefore, a casting should be designed so that the pattern will have its parting in one plane, if at all possible. This is especially desirable for match-plate, machine molding. With large castings, weighing several tons, which cannot be made by machine molding, straight parting lines are desirable but to a slightly less degree than in machine molding.

Distortion Allowances. In certain types of castings, such as those having large flat areas or those of U-shape, it is often necessary to purposely distort the pattern to secure a straight casting. The amount of distortion is called distortion allowance (also referred to as "faking" the pattern). It is well for the engineer to be guided in the application of such allowances by the advice of the foundryman and patternmaker, as there are no fixed rules governing such allowances.

Machine Finish Allowance. When portions of castings are to be machined, patterns are constructed so that excess metal is provided for that purpose on the sections to be so treated. This allowance, commonly called "finish," depends on (a) the metal used, (b) shape of the part, (c) size of part, (d) tendency to warp and (e) machining method or set-up.

Wherever possible, the casting should be designed in such a manner that surfaces to be machined can be cast in the drag section of the mold. When there is no way to avoid casting such surfaces in the cope, an extra allowance for finish should be made. Allowances for finish are not covered by fixed rules because they involve many variables. The matter is one to be agreed upon in conference with the foundryman.

Draft. Draft is the taper which must be allowed on all surfaces of a pattern, disposed approximately parallel to the direction in which the pattern is drawn, to permit withdrawal of the pattern from the sand without tearing the mold. Fig. 10 illustrates the result of withdrawing a pattern from the mold when no draft was allowed on the pattern. Fig. 11 illustrates how the mold retains its shape upon withdrawal of a well-drafted pattern. Regardless of the type of pattern equipment to be used, draft must be considered in all casting designs. Normally, draft is added to the design dimensions.

Machine or high-production (match-plate) patterns require less draft than patterns of other types. In green sand molding, interior surfaces of all types of patterns usually require more draft than exterior surfaces. The amount of draft usually required on high-production match-plate work is about 2 deg. With experience, however, it is possible in some instances to reduce the draft to 1 deg. It is a good rule to allow as much draft as possible, even exceeding the 2 deg. noted, providing it does not affect the section size variation too much or impair the usefulness of the casting.

Core Prints and Boxes

Core Prints. Cores are masses of sand placed in molds to create cavities or recesses at desired locations in castings. When dry sand cores are required in a casting, provision must be made in the pattern for prints to provide anchorages or supporting recesses in the mold. In addition, core boxes must be con-

structed for making the cores and, in many instances, core dryers also must be provided. Fig. 12 shows a core box and a core dryer for an automotive engine manifold core. Core dryers are metal supports, usually made of a light metal, such as aluminum, in which the unbaked cores are mounted during the baking operation to prevent the core from sagging and warping.

Core Boxes and Dryers. If cores are of such a shape that they may be set upside down or wrong end to, locating or indexing lugs to insure proper setting should be provided on the pattern, in the core box and in the core dryer. The same draft should be allowed in core boxes as in patterns, namely, about 2 deg.

When the venting of cores can be determined in advance, it is desirable to discuss this subject with the foundryman and have vents indicated on the core prints by means of strips or projections, and in the core boxes by some appropriate means.

Locating Points. When possible, locating points to be used by the machine shop should be indicated on the drawing so that castings and patterns always may be checked satisfactorily from the same point of origin by the pattern shop, foundry and machine shop. An effort should be made to place all locating points on the same side of the parting line. In other words, locating points should be so placed that they will not be influenced by a shift of a core, the cope or the drag. The points should be as far apart as the size of the casting permits, as this insures the most accurate results. Points on the casting having no finish allowance and to be held to close limits, should be chosen for locating points when designing fixtures. Jig spots are important items frequently neglected until the casting is made, with the possibility of considerable subsequent loss.

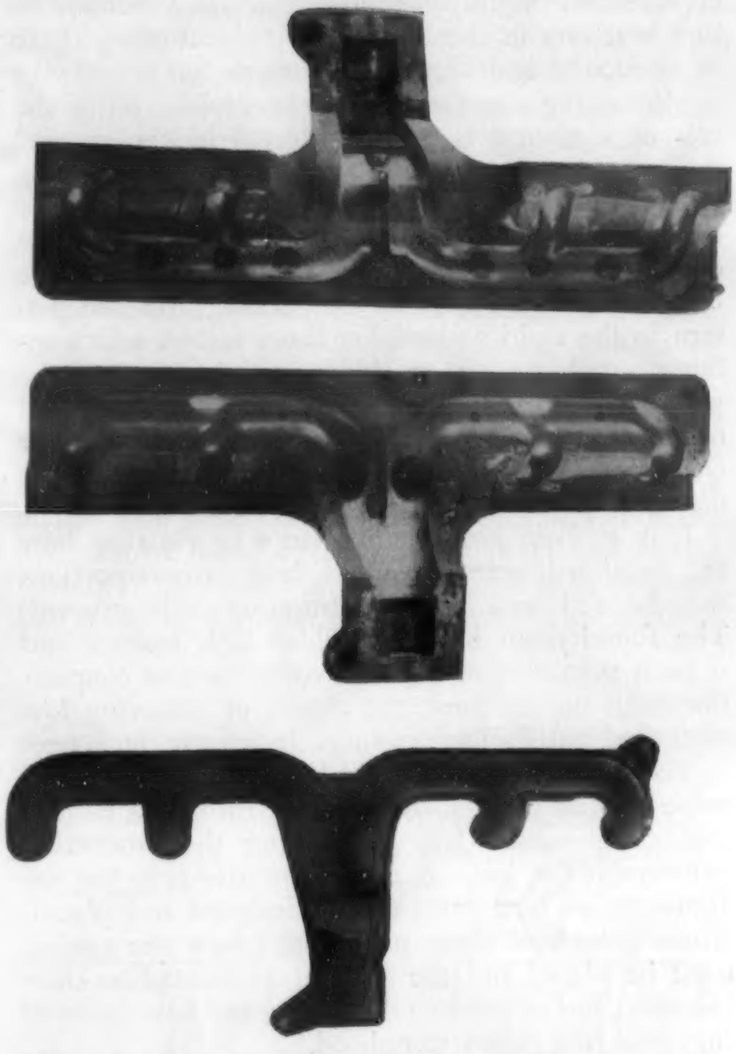

Fig. 12. Core box used for producing automotive manifold cores. The lowest view shows the core resting in a form called a "dryer," which prevents the core from warping while it is being dried.

Casting Design Recommendations

Metallurgical Considerations. Casting design must include consideration of the metallurgical features involved because they influence greatly the recommendations here made. In any casting, however, regardless of the metal from which it is made, the design should be such that the metal in the mold will solidify progressively from the lowest to the highest portion of the casting, as it sets in the mold. This is a paramount consideration in the design of any casting and the one which influences practically all rules of design.

From the foundryman's viewpoint, the ideally designed casting is one of such shape and thickness that the casting can be:

1. Poured easily in all its parts.
2. Cast without the use of risers or with not more than one (depending on the metal) located at the casting's highest point in the mold.
3. Made to solidify regularly and progressively from the lowest to the highest point in the casting.
4. Poured in such a manner that the last fluid metal will be in the riser.
5. Cleaned with minimum difficulty.

Solidification Factors. The solidification of any cast metal, neglecting mold influences, is dependent primarily on three factors, namely, (1) pouring temperature, (2) solidification time (section size) and (3) solidification range of the metal involved.

The designer has no control over the pouring temperature. That is the province of the foundryman. Likewise he has no control over the solidification range of the metal used, which is inherent in the metal. He does have control, however, of the solidification time as this is dependent in general on the thickness of the sections of the casting.

In any casting, the thin sections freeze first and draw metal to compensate for their liquid shrinkage from the still-liquid metal in heavier sections. If these heavier sections are not so placed that they can be fed adequately by risers, they will contain defects. Furthermore, if these heavy sections are not so placed in the mold that they solidify progressively from the lowest to the highest portions, defects also will be present. Hence, the necessity for considering how the casting can be molded to secure progressive directional solidification when it is being designed. This may be accomplished by making the section

cross-section slightly wedge-shaped from bottom to top as it sets in the mold, as by accentuating draft in horizontal and vertical sections.

Visualizing the Casting in the Mold. Since the cost of a casting is greatly affected by the cost of making the mold, it follows that anything that the casting designer can do to lower mold cost will be reflected in lowered molding cost and consequent lower cost per casting produced. For this reason, if the designer tries to visualize the casting and the pattern in the mold and studies those factors which influence molding cost, including the removal of the pattern from the mold, the setting of the cores, and other supplementary operations, he has a much better chance to lower the cost of the casting than if he disregards such matters.

It is of even greater importance to visualize how the metal will enter the mold, how various portions will be fed and how solidification will proceed. The foundryman has to consider such matters and if he is permitted to do so in conference or cooperation with the designer, the chance of achieving low costs and satisfactory castings is greatly increased.

Visualization can be aided by the use of a model made to scale or full size or in the form of a pattern that can be used later in making the production pattern for the job. A model can also help the designer to see how cores can be designed and placed, where gates and risers must come, how the casting must be placed and the pattern constructed to clear the mold and secure sound castings, and how the castings will look when completed.

Rules for Design

In general, castings are complicated structures containing several members. Recognizing this fact, and after considerable experimentation, the U. S. Navy has recommended seven design rules for steel castings, which seem applicable to castings quite generally:

1. An attempt should be made to design all sections in a casting with a uniform thickness.

2. It is not desirable to design structures with abrupt changes in section.

3. Sharp corners at adjoining sections should be eliminated if possible.

4. When the design of a cast steel structure becomes very complicated or intricate, it is suggested that it be broken up into parts so that they may be cast separately and then assembled by welding or bolting.

5. In designing unfed sections in "L" or "V" shapes, it is suggested that all sharp corners at the junction be replaced by radii so that this section becomes slightly smaller than that of the arms.

6. In designing sections that join in an "X"-section, it is suggested that two of the arms be offset considerably.

7. In designing any joining sections, it is suggested that all sharp corners at the junctions be replaced by radii. In the case of unfed "T" and "X" sections, these radii should not be large.

The first three of these rules are probably the most important although the others are only slightly less so. In steel castings, the rules assume equal importance.

Uniformity of section thickness is important in any casting because, in addition to the shrinkage difficulties previously referred to, any metal just after solidification is at its lowest tensile strength. Sometimes the effects of variations in section thickness can be compensated for by the foundryman through the use of chills, providing the variations are not too great. This, however, involves additional cost, which the designer should consider. The design and use of chills, where necessary, should be left to the foundryman and his metallurgist. Section uniformity is the best way to avoid the use of chills.

Section Thickness. The best practice in regard to section thickness is to use the minimum which will provide the necessary strength, stiffness and weight without requiring excessive pouring temperatures. High pouring temperatures in some metals result in abnormal physical properties. Again, some metals, such as certain gray irons, are more susceptible to variation in properties across a given section than others. Generally, although not always, the high-strength irons possess more nearly uniform physical properties throughout the section than do the lower strength irons. Then, too, some irons which are gray in heavy sections, are white or mottled (part white and part gray) if poured into thin sections, showing that the rate of cooling affects structures and has, in turn, a marked effect upon hardness, machinability and other properties. In gray iron, however, hardness is not necessarily an index of machinability.

Incidentally, in gray iron, there is another reason why too great a variance of section should be avoided. It often is difficult, without additional cost, to make and control an iron which will give the properties required in all sections when sections vary greatly in thickness. Where this does occur, the casting may contain gray, mottled and white sections, the latter being practically unmachinable. This particular difficulty of melting and control, as experienced in gray iron, is not so pronounced in the other metals, although shrinkage difficulties, previously mentioned, are still present.

Minimum Section Thickness. There are no well defined minimum section thicknesses which are feasible to cast even for a particular type of metal or alloy, as the size, intricacy and application of the castings, and detailed composition of the metal, are the real factors which determine minimum section thickness. The following are the normal minimum section thicknesses for various general classes of metals cast in sand and *are given as a guide only:*

Recommended Minimum Sections for Cast Metals

Material	Normal Minimum Section Thicknesses, In.
Gray cast iron (soft)	1/8
White cast iron	1/8
Malleable iron	1/8
Steel	3/16
Brass and bronze	3/32
Aluminum	1/8

It should be remembered that the relation of cross section of the various members in a design has as much to do with the minimum section thickness permissible within that design as any other factor, although this relation may dictate sections heavier than the normal minimum possible. The use of chills also has an effect on the minimum section possible within a design.

It is again emphasized that the figures in the above table are *normal* minimum sections, but thinner sections can be cast under certain circumstances. Thus, for example, sand castings of small size, such as some found in low-priced door locks made of gray iron, have sections as thin as 1/16 in., but they constitute an exceptional case.

Economy in metal and hence in weight, of course, dictates the use of the thinnest sections which can be employed and still afford adequate strength, stiffness, and other properties necessary in the design. Naturally, there is no point in specifying a section so thin that it cannot be cast. A competent foundryman should be consulted before the final design is made.

It should also be remembered that certain metals are more sensitive than others to variation in section thickness. This is particularly true in the case of a gray iron as has been noted elsewhere. In the casting of steel, extremely thin sections require high pouring temperatures which tend to produce abnormalities. In the casting of any metal, the thinner the wall section, the greater the chilling effect of the mold walls on the metal, and the lower the pouring temperature of the metal, the greater is the mold wall effect. This being the case, the designer should not recommend sections so thin that they have a tendency to remain unfilled. Such designs result in high scrap losses and higher net cost than if the thin section is made somewhat thicker.

Member Junctions. Irregularly situated heavy sections, connected by thin members, result in a series of localized hot spots during cooling, thus preventing the regular and progressive solidification of the casting desired and often resulting in rupture at or near junctions because of contraction stresses, as previously noted.

Where light and heavy sections are unavoidable, the transition from one to the other should be as gradual as possible. This may be accomplished by tapering sections or by proper fillets or by both. If the blending of sections cannot be attained, fillets should be used at junctions, especially at interior corners but fillets should not be so large as to result in undue thickness of section at junctions. Sharp corners in any design are to be avoided. Fatigue testing has demonstrated that sharp corners result in stress concentrations. In a casting, this condition is exaggerated because of the manner in which the metal solidifies around the corner.

Solidification generally progresses from the mold face inward. At a sharp corner, crystals form in such a way as to constitute planes of weakness. In some metals, steel for example, this weakness is difficult to overcome, but in alloys with a narrow freezing range, such as high conductivity copper alloys, this weakness is not so pronounced, although still present.

For these reasons, engineers should use fillets at member junctions regardless of whether tapering sections can be used or not. Fig. 13 illustrates the types of fillets and radii found to produce the best results in steel castings in an investigation of this problem by the U. S. Naval Research Laboratory. In the author's opinion, the same general design principles should be considered in joining sections of castings made from other metals.

Cross Members. Fig. 14 represents a right-angled crossing of members of equal thickness, such as those frequently found in the re-enforcing ribs under a plate. The mere crossing of the members increases the mass of metal at the crossing point and retards cooling of the metal at that point. It is to be noted that radius S_2 is greater than radius S_1. The condition

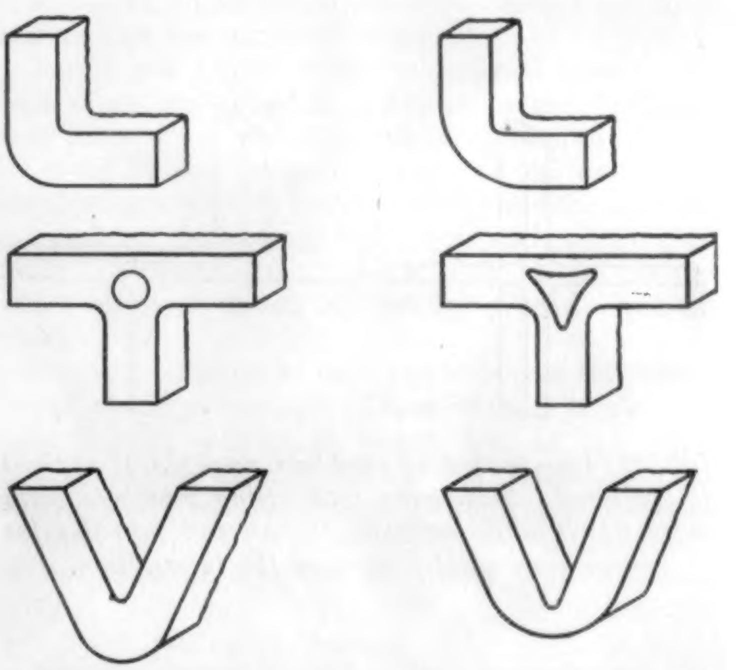

Fig. 13. Methods of securing equalization of cooling stresses and acceleration of solidification in various types of joined members. Designs on the left are considered to be the best and most practical; those on the right are satisfactory. Where heavy sections of several inches thickness are joined, a core is used at the juncture to equalize section thickness. (U. S. Naval Research Laboratory for Steel Castings)

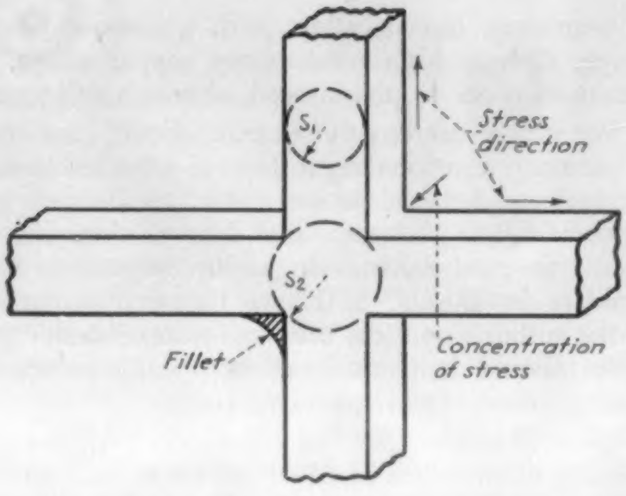

Fig. 14. Concentration of stress occurs at an angular connection. Use of fillets helps to secure stress distribution. Circles with radii S_1 and S_2 are drawn to show increase in section size. Radius S_2 is greater than S_1, illustrating that the mere crossing of sections increases section size.

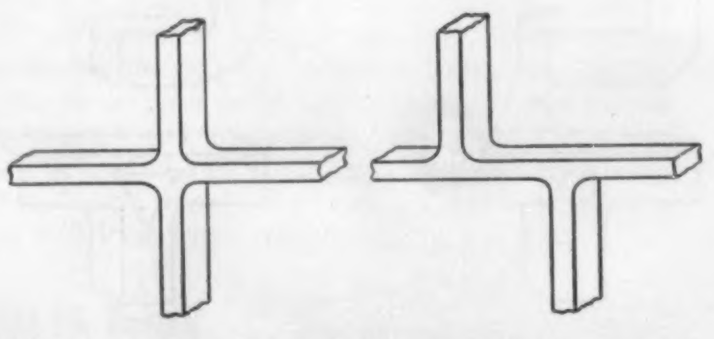

Fig. 15. Intersection of members arranged as at right is preferred. Staggering intersecting members gives more nearly uniform metal section and provides for more even solidification at the intersection.

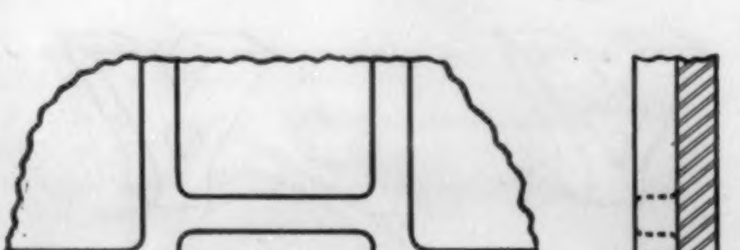

Fig. 16. Staggering ribs and webs promotes uniformity in rate of cooling.

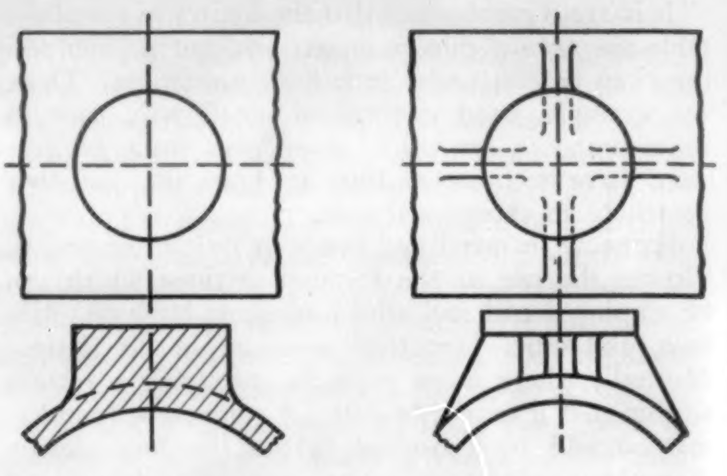

Fig. 17. Designs for bolting or bearing bosses. That at left is poor because of the thickened section at the boss. That at right is good, even though it involves the use of cores, because it promotes section uniformity.

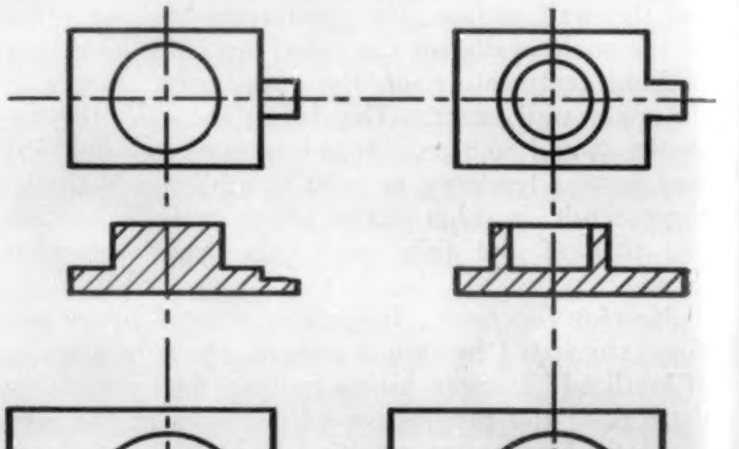

Fig. 18. Bosses on large castings. Those at left are common designs but are unsatisfactory because they involve at the bosses metal sections thicker than the main casting section through which the bosses are fed. The heavier metal sections of the bosses may have defects because of inadequate feeding. Those at right are designed to give more nearly uniform metal sections and permit sound castings to be made with less weight and lower machining cost.

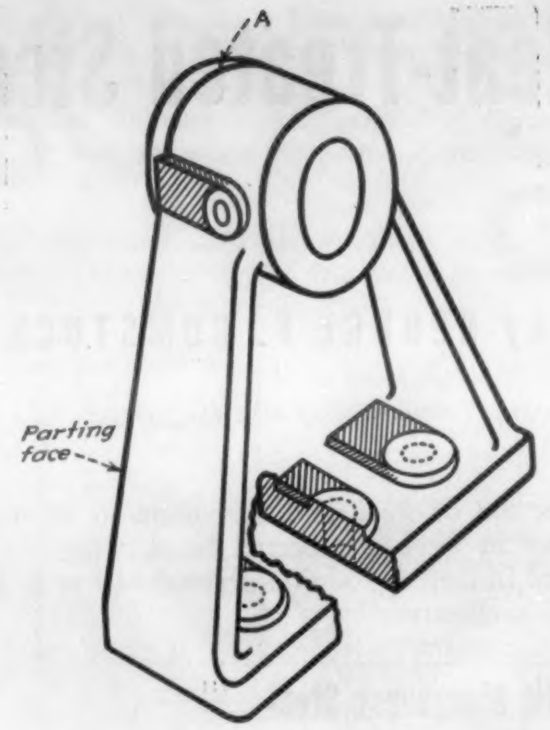

Fig. 19. Casting with bosses which, if left circular, requires loose pieces on the main pattern, entailing additional pattern cost for loose sections and higher molding cost. If sections between bosses and parting face are filled in, the boss section can be solid with the pattern, making for ease in molding. The parting line is shown at A. Wide variation in section thickness is unfavorable and might be avoided, especially if castings were cored out on underface, although this might increase cost.

may even be aggravated when liberal fillets are used and applies to all cases where members intersect.

Often it is feasible to avoid the crossing of members by staggering them so that the casting will have the desired stiffness and other properties without being injuriously affected by hot-spots. (Figs. 15 and 16) Where staggering cannot be done because of dimensional restrictions, the next best procedure is to form a depression or core a hole at the crossing point; so as to accelerate solidification and to better equalize the cooling stresses, by removing some of the metal at the critical point.

Ribs, Bosses and Lugs

Ribs. Ribs are used primarily as stiffeners and reinforcing members. In certain castings, the tendencies of large flat areas to distort, when cooling from casting temperature, may be eliminated by properly designed and correctly located ribs. Rib construction may also be used to advantage to reduce weight of castings and attain section uniformity. The relationship of rib section to main section should be such as to permit as far as possible, a uniformly graded metal section. Where feasible, rib intersections should be staggered. T and H-shaped ribbed designs have the advantage of uniform metal sections and hence uniform cooling.

In average designs the preference is for ribs having depth considerably greater than thickness. It should be remembered that thin ribs, while accomplishing the desired early solidification for keeping the piece from warping, often causes high solidification stresses to be set up where the rib joins the body of the casting. Rules discussed under member junctions apply to the junction between ribs and casting. Ribs should be proportioned, in general, in such a manner that their thickness approaches that of the section to which they are joined as is advocated for the joining of major castings sections.

Fig. 16 illustrates the manner in which ribs on a flat plate should be staggered to promote equalization of sections. Fig. 17 illustrates the use of rib construction to equalize section thickness at a boss. In this case, supporting rib construction, as illustrated at the right of Fig. 17, is used under a pad or flange to avoid the thick section in the original design as shown on the left of the same figure. It should be noted that in the ribbed design, the boss surface area has not been decreased.

Bosses and Lugs. Properly designed bosses and lugs often are of great assistance to the foundryman in reducing molding costs. An attempt should be made by the designer to promote uniformity of metal section between bosses and lugs and the body of the casting. Such a practice allows such projections to be fed properly through the body of the casting which in turn should be fed by properly located risers.

Fig. 18 illustrates two types of bosses often found on large castings. Those designs at the left have heavier sections at bosses than in the main casting section through which the bosses are fed. Such designs, for this reason, invite defects. Designs on the right are such as to equalize the solidification, as less metal need be fed because of uniform metal section. Less metal is required and, of course, the weight of casting is lowered.

Some engineers appear to have a preference for round bosses. If such bosses, or any other type, can be cast without the necessity of loose pieces on the pattern, there is no reason why they cannot be used providing they are properly blended into the section on which they occur.

Loose Pieces. Any design requiring the use of loose pieces in pattern construction and in molding costs more to produce than a corresponding one in which such features are not necessary. When the mold is made for a design involving the use of loose pieces, the latter remain in the mold when the pattern is withdrawn. Additional time is consumed in drawing the loose pieces, thus increasing the molding time and hence casting cost.

In the casting, Fig. 19, the bosses are required to be round, and they must be molded as loose pieces on the main pattern. Such designs involve higher pattern cost and additional molding cost. The use of loose pieces, though often necessary, not only increases the casting cost but also, in many instances, is the cause of an inferior product.

(To be concluded)

Boron plus Titanium in Heat-Treated Steels

Paralleling the wartime development of the low-alloy, high-hardenability NE steels in its potential importance to engineers has been the growing use of boron additions to produce no-alloy or low-alloy steels of high hardenability. Many companies — steelmakers, steel-users and ferroalloy producers — have participated in this development, taking different approaches but coming out in the same general neighborhood. Mr. Comstock reports in this article on the hardenability and engineering properties of steels treated with ferroalloys containing both boron and titanium, and includes some interesting comparisons with other means of improving hardenability.

—The Editors

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THE USE OF SMALL AMOUNTS of boron for improving the properties of quenched and tempered steel has made great progress in the last 18 months. In January, 1942, the writer published a paper[1] in *Metals Technology,* showing the value of this element especially when used in combination with titanium and other deoxidizers. Very informative statements on this subject by Crafts[2], Demmler[3], and Tisdale[4] have appeared more recently, and an excellent summary of the situation has been provided by the American Iron and Steel Institute[5]. The present article may serve to indicate how some of the newer boron alloys may be used to improve the properties of certain alloy steels, and especially how molybdenum, which is becoming scarce because of excessive use, may be saved by that means.

The tests here reported, except where specially noted, were made with small heats of steel melted in an induction furnace, and forged into ⅞-in. round bars, which were normalized at 1650 deg. F. before further heat treatment and testing. All the steels were deoxidized with aluminum, and, therefore, were fine-grained, and the boron alloys were added after the aluminum and just before pouring the ingots. The compositions of the alloys used were as follows:

	C	Mn	Si	Al	Ti	B
Bortam	0.10	22.58	20.14	14.11	17.85	1.86
Carbortam	7.64	0.20	2.36	1.00	17.58	0.59

A special alloy like Bortam but containing zirconium instead of titanium was also tried as will be noted later. Bortam was used in amounts equivalent to 5 lbs. per ton of steel, and Carbortam to 10 lbs. per ton, but in large commercial heats, which are less oxidized in melting, additions about half as large are generally effective.

Pearlitic Manganese Steel

Boron-bearing alloys were first used commercially as additions to steel by the automobile industry in pearlitic manganese steel, and they are especially effective in that grade. A pertinent comparison is afforded by Fig. 1, showing how treatment of a 1.26 per cent Mn steel with Carbortam gave even better hardenability than was obtained with an untreated steel containing much higher manganese, or 1.83 per cent. A corresponding increase in hardenability was secured by treating the 1.83 per cent Mn steel with Carbortam.

Table 1 gives some of the physical properties of these steels, and shows how much tougher the Carbortam-treated steel No. 2 was than the untreated steel No. 3 wit hthe manganese increased about 0.6 per cent to give equal strength after quenching and tempering. Here even superior physical properties are provided by the boron alloy treatment, with at the same time a marked saving in the strategically-important manganese. A similar comparison can be derived from the author's A. I. M. E. paper[1] between boron-treated 1.12 per cent Mn steel and non-boron steel containing about 0.7 per cent more manganese, or 1.85 per cent.

Silicon and Higher-Carbon Steels

One of the chief advantages of the boron-alloy treatment of steel, as compared with the use of other alloys for conferring hardenability, is generally a higher notched-bar impact resistance when the steels are quenched and tempered for high strength and hardness. However, a material improvement in this respect is not always found in steels of very low toughness. Silico-manganese steel with 2 per cent Si, for instance, does not respond as favorably as lower-silicon steels to the boron-alloy treatment, and neither do steels with 0.62 per cent or more carbon. Hardenability curves for steels of this nature are shown in Fig. 2, and Table 2 gives their physical properties after oil-quenching and tempering as noted.

The high silicon steels Nos. 5 and 6, as may be noted in Table 2, had much better properties than the higher carbon steels Nos. 7, 8 and 9 when tempered at 600 deg. F. to Rockwell C hardness of about 55, but not when tempered at 900 deg. F. to Rockwell C hardness of about 40. The Bortam treatment produced a slight improvement in toughness and ductility after tempering at 600 deg. F. in both kinds of steel, without much difference in strength. After tempering at 900 deg. F., however, the steels Nos. 5, 6, and 7 with either high silicon or 0.20 per cent Mo were definitely stronger and less tough and ductile than the boron-alloy treated steels Nos. 8 and 9. Fig. 2 shows that the boron treatments gave

Fig. 1. Hardness distribution along sides of end-quenched specimens of the pearlitic manganese steels described in Table 1.

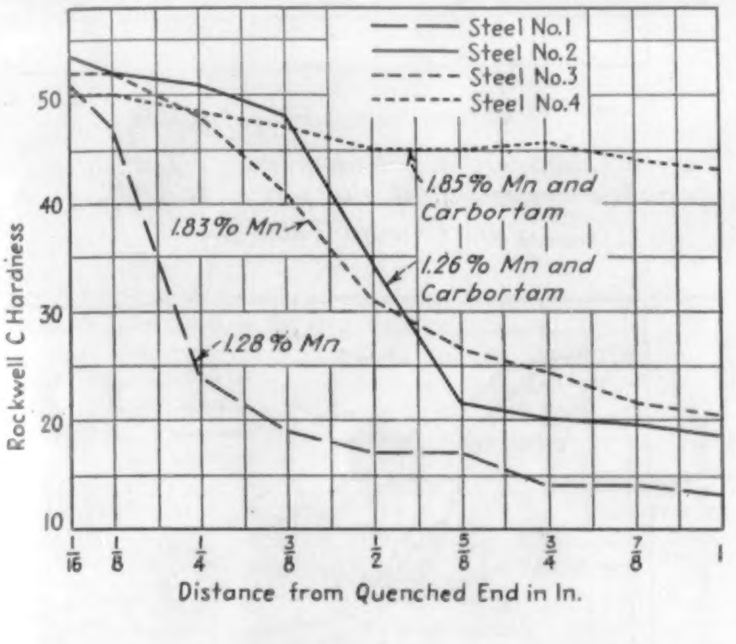

Fig. 2. Hardness distribution along sides of end-quenched specimens of the silicon and 0.63 per cent C steels described in Table 2.

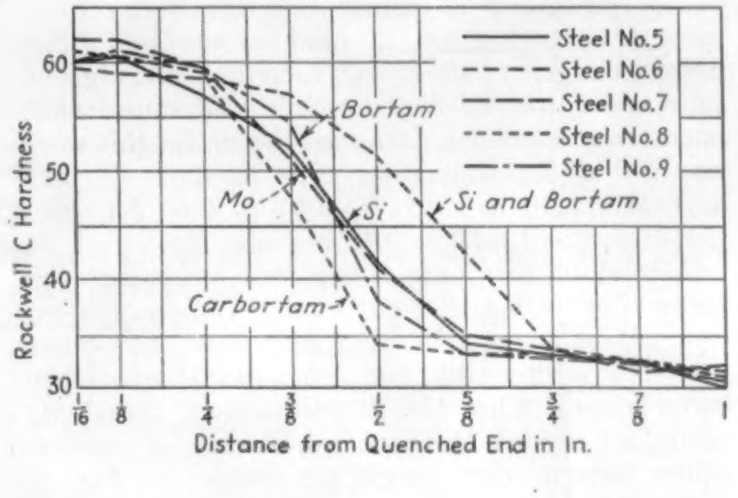

Table 1.—Results of Tensile, Hardness, and Impact Tests on Pearlitic Manganese Steels, Oil-Quenched from 1550 deg. F. and Tempered as Noted.

Steel No.	Chemical Analysis, %			Boron Alloy Treatment	Tempering Temperature, ° F.	Yield Point, p.s.i.	Tensile St'gth, p.s.i.	% Elongation in 2 in.	% Reduction of Area	Rockwell C Hardness	Izod Impact Value, Ft.-Lbs.
	C	Mn	Si								
1	.38	1.28	.31	None	450	99300	140000	13.5	41.7	47.0	10.7
2	.36	1.26	.29	Carbortam	450	234000	259000	12.0	48.1	49.0	18.0
3	.37	1.83	.20	None	450	212000	256000	12.5	45.6	49.0	8.3
4	.38	1.85	.21	Carbortam	450	236000	258000	11.5	47.7	49.0	15.3
1	.38	1.28	.31	None	900	95900	117000	20.0	59.0	30.0	51.3
2	.36	1.26	.29	Carbortam	900	138000	142000	18.0	54.2	31.0	51.7
3	.37	1.83	.20	None	900	137500	146000	19.0	55.0	31.0	40.0
4	.38	1.85	.21	Carbortam	900	142500	149000	17.5	51.0	32.0	35.0

Table 2.—Results of Tensile, Hardness, and Impact Tests on Silicon and 0.63 per cent C Steels, Oil-Quenched and Tempered as Noted.*

Steel No.	Chemical Analysis, %				Boron Alloy Treatment	Tempering Temperature, ° F.	Yield Point, p.s.i.	Tensile St'gth, p.s.i.	% Elongation in 2 in.	% Reduction of Area	Rockwell C Hardness	Izod Impact Value, Ft.-Lbs.
	C	Mn	Si	Mo								
5	.58	.82	1.92	..	None	600	304500	323000	4.5	25.3	57.0	4.3
6	.56	.91	2.01	..	Bortam	600	304000	324000	6.0	31.8	56.0	5.3
7	.67	.82	0.30	.20	None	600	251000	268000	0.5	2.3	54.0	2.3
8	.62	.88	0.34	..	Carbortam	600	264000	276000	0.5	3.1	51.0	3.0
9	.63	.84	0.36	..	Bortam	600	243000	274000	1.3	3.6	46.0	2.8
5	.58	.82	1.92	..	None	900	164000	195000	12.0	27.4	36.0	9.3
6	.56	.91	2.01	..	Bortam	900	155000	194000	11.5	27.2	40.0	5.3
7	.67	.82	0.30	.20	None	900	161000	197000	11.5	35.5	41.0	13.3
8	.62	.88	0.34	..	Carbortam	900	148500	171900	14.5	46.9	38.0	18.3
9	.63	.84	0.36	..	Bortam	900	150700	176000	13.5	40.1	37.0	16.7

* Note:—The high silicon steels were quenched from 1600 deg. F., and the others from 1550 deg. F.

about the same hardenability as either 0.20 per cent Mo in steel No. 7 or 1.6 per cent extra silicon in steel No. 5, but with both high silicon and Bortam treatment as in steel No. 6, superior hardenability was attained.

Nickel-Chromium NE Steel

The equivalent hardenability produced by the boron alloys in heats Nos. 8 and 9 as compared with 0.20 per cent Mo in heat No. 7 is of particular interest, since the use of molybdenum is often specified for promoting that property, or deep hardening of larger sections, and the use of the boron alloys is much more economical.

The possibility of substituting the boron treatment for molybdenum in some of the new "National Emergency" steels was, therefore, investigated, since saving molybdenum in them is of considerable importance at present. One steel chosen for this work was NE 8744, containing 0.40 to 0.47 C, 0.75 to 1 Mn, 0.20 to 0.35 Si, 0.40 to 0.60 Ni, 0.40 to 0.60 Cr, and 0.20 to 0.30 per cent Mo.

A steel of that composition was compared with boron-alloy-treated steels of similar composition except without any molybdenum. Bortam and Carbortam were used in this work, and also a special low-carbon boron-bearing alloy like Bortam except containing zirconium instead of titanium. Results of hardenability tests of these steels are plotted on Fig. 3, and those of the other usual tests are given in Table 3.

The properties of the boron-treated nickel-chromium steels, as reported in Table 3, compare fairly well with the regular NE 8744 steel No. 10 with 0.24 per cent Mo, especially after tempering at 450 or 600 deg. F. to Rockwell C hardness not less than 47. When tempered at 900 deg. F. to lower hardness the molybdenum steel was definitely stronger, though less resistant to impact. This is also illustrated in Fig. 3, where it is clearly seen that the boron-treated steels maintain their hardness above 50 Rockwell C to the same distance from the quenched end as the molybdenum steel, but are decidedly softer than the molybdenum steel at 1 or 2 in. from the quenched end where the cooling was less rapid.

Thus while the boron treatment gave just as much hardenability as 0.24 per cent Mo in this steel at the higher hardness levels, it did not cause the steel to maintain its hardness so well with slower rates of cooling. When tempered to below about 45 Rockwell C, therefore, the boron-treated steel would have to be tempered at a lower temperature than the molybdenum steel to have the same hardness and strength.

It may be noted that the special boron alloy containing zirconium instead of titanium, but otherwise like Bortam, gave equivalent hardenability and strength in steel No. 13, but less reduction of area after tempering at 450 or 600 deg. F., and lower impact value after tempering at 900 deg. F. It seems, therefore, that a titanium-boron alloy gives on the whole better results than a zirconium-boron alloy.

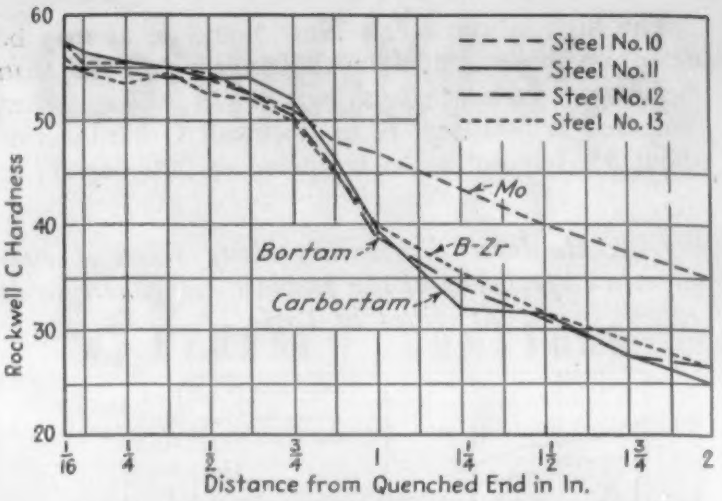

Fig. 3. Hardness distribution along sides of end-quenched specimens of the nickel-chromium steels described in Table 3.

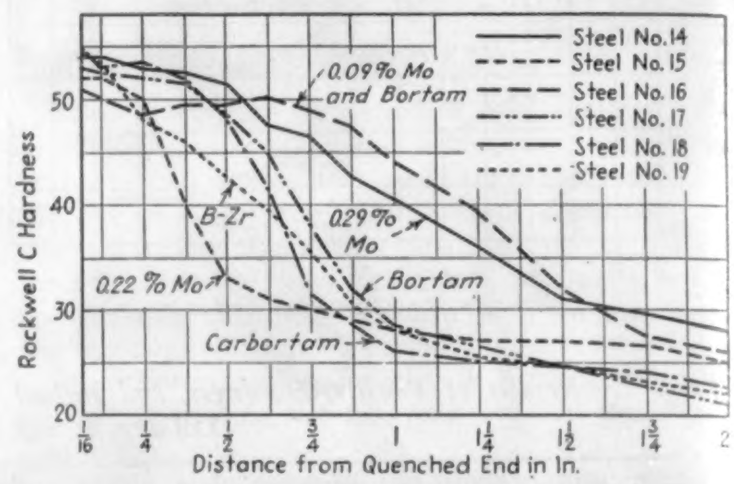

Fig. 4. Hardness distribution along sides of end-quenched specimens of the 0.42 per cent C, 1.5 per cent Mn steels described in Table 4.

The desirability of using titanium with boron in steel has also been pointed out in the author's previous paper published by the A. I. M. E.[1]

Manganese-Molybdenum NE Steel

These relations have also been checked by other tests, and some similar results on NE 8339 steel are reported as further examples. This is a 0.40 per cent C manganese-molybdenum steel, which, though reported to be highly useful, has recently been deleted from the approved list of "National Emergency" steels because of the scarcity of molybdenum. The data in Table 4 and Fig. 4 show how little the properties of this steel are affected by reducing the molybdenum to residual percentages obtainable from scrap, or even by eliminating molybdenum altogether, provided treatment with a titanium-boron alloy is substituted.

The striking difference in hardenability between steels No. 14 with 0.29 per cent Mo and No. 15 with 0.22 per cent, as shown on Fig. 4, was checked with duplicate test specimens cut from another part

Table 3.—Results of Tensile, Hardness, and Impact Tests on 0.5 per cent Ni, 0.5 per cent Cr Steels, Oil-Quenched from 1550 deg. F. and Tempered as Noted.

Steel No.	Chemical Analysis, % C	Mn	Si	Mo	Boron Alloy Treatment	Tempering Temperature, ° F.	Yield Point, p.s.i.	Tensile St'gth, p.s.i.	% Elongation in 2 in.	% Reduction of Area	Rockwell C Hardness	Izod Impact Value, Ft.-Lbs.
10	.46	.89	.26	.24	None	450	276000	284000	8.5	35.7	50.5	12.7
11	.47	.87	.25	..	Carbortam	450	279000	288000	8.5	31.8	51.0	12.0
12	.46	.97	.27	..	Bortam	450	220000	276600	11.0	41.7	49.5	15.7
13	.42	.93	.29	..	Special B-Zr	450	267000	279000	8.0	27.4	50.5	16.7
10	.46	.89	.26	.24	None	600	231000	257600	9.0	39.4	49.5	8.0
11	.47	.87	.25	..	Carbortam	600	220000	252000	7.5	30.4*	47.0	7.7
12	.46	.97	.27	..	Bortam	600	223000	251000	8.5	36.8	47.5	11.3
13	.42	.93	.29	..	Special B-Zr	600	245000	250000	7.5	31.1	47.0	8.3
10	.46	.89	.26	.24	None	900	176800	189800	13.5	45.1	38.0	26.0
11	.47	.87	.25	..	Carbortam	900	149700	164800	14.5	45.6	32.0	38.0
12	.46	.97	.27	..	Bortam	900	151000	162100	15.0	49.6	34.0	31.7
13	.42	.93	.29	..	Special B-Zr	900	149200	162100	14.0	45.3	34.0	24.3

* Note:—Slight flaw in this fracture.

Table 4.—Results of Tensile, Hardness and Impact Tests on 0.42 per cent C, 1.5 per cent Mn Steels, Oil-Quenched from 1550 deg. F. and Tempered as Noted.

Steel No.	Chemical Analysis, % C	Mn	Si	Mo	Boron Alloy Treatment	Tempering Temperature, ° F.	Yield Point, p.s.i.	Tensile Str'gth, p.s.i.	% Elongation in 2 in.	% Reduction of Area	Rockwell C Hardness	Izod Impact Value, Ft.-Lbs.
14	.43	1.46	.21	.29	None	450	257500	271000	9.5	44.1	51.0	13.3
15	.43	1.45	.27	.22	None	450	256000	269000	8.5	39.0	50.0	7.2
16	.41	1.54	.28	.09	Bortam	450	248000	261500	9.5	42.4	49.0	17.2
17	.43	1.57	.26	..	Bortam	450	253500	268500	11.0	45.7	49.0	13.3
18	.43	1.48	.22	..	Carbortam	450	259500	272000	8.5	38.0	50.0	18.2
19	.42	1.57	.30	..	Special B-Zr	450	256000	268000	9.0	42.6	49.0	6.5
14	.43	1.46	.21	.29	None	600	218300	240700	10.0	43.9	47.0	9.8
15	.43	1.45	.27	.22	None	600	187000	214500	8.5	41.2	47.0	5.5
16	.41	1.54	.28	.09	Bortam	600	205900	231700	10.0	47.1	46.0	14.2
17	.43	1.57	.26	..	Bortam	600	212300	235200	11.0	45.8	45.0	10.7
18	.43	1.48	.22	..	Carbortam	600	211300	235500	8.0	40.1	47.0	12.5
19	.42	1.57	.30	..	Special B-Zr	600	210100	234000	10.0	44.4	45.0	6.0
14	.43	1.46	.21	.29	None	900	172200	180600	14.0	46.0	39.0	32.3
15	.43	1.45	.27	.22	None	900	164000	172200	14.5	48.5	37.0	32.8
16	.41	1.54	.28	.09	Bortam	900	145500	157900	15.0	53.3	34.0	38.7
17	.43	1.57	.26	..	Bortam	900	142500	172700	17.0	55.9	33.0	37.5
18	.43	1.48	.22	..	Carbortam	900	151400	156800	16.0	49.5	32.0	41.2
19	.42	1.57	.30	..	Special B-Zr	900	138600	150900	16.0	52.0	31.0	41.5

of the forged bars, but seems entirely too large to be explained by only 0.07 per cent difference in molybdenum content. It could not, however, be explained by other differences in the compositions of the steels. The analyses were checked with samples drilled from the actual hardenability test specimens, and the only difference in unintentional impurities between the two steels found with the spectrograph was in the aluminum content. Since the same small amount of aluminum was used in both heats, and the resulting content was very low, it is concluded that the abnormally large difference in hardenability must be due in part to a different degree of oxidation of the two heats in melting, so that some of the hardening elements occurred in a less effective form, or perhaps partly as oxides, in steel No. 15.

The agreement in hardenability between the boron-treated steels Nos. 17 and 18 is interesting by contrast, and this was also checked by several other similarly-treated heats which were not included in Fig. 4 to avoid excessive complexity of the chart. Throughout this work, it has been found decidedly more difficult to secure consistent check results on the hardenability of molybdenum steels than on that of boron-alloy treated steels, so that the boron-alloy treatment seems to have a definite advantage for promoting uniformity between individual heats of steel.

The results in Table 4 agree with those reported on the other kinds of steel in showing that the boron-alloy treated steels compare favorably with the molybdenum steels when tempered at 450 or 600 deg. F., but when tempered at 900 deg. F. to a Rock-

Table 5.—Results of Tensile and Impact Tests on Cast Manganese-Molybdenum Steels, Water-Quenched from 1650 deg. F. and Tempered as Noted.

Steel No.	Chemical Analysis, %				Boron Alloy Treatment	Tempering Temperature, ° F.	Yield Point, p.s.i.	Tensile Str'gth p.s.i.	% Elongation in 2 in.	% Reduction of Area	Izod Impact Value, Ft.-Lbs.
	C	Mn	Si	Mo							
20	.26	1.68	.55	.33	None	1200	89600	106700	22.0	46.5	45.0
21	.28	1.66	.53	.18	Carbortam	1200	89800	105000	22.5	46.7	45.0
22	.26	1.47	.49	.04	Carbortam	1200	79000	97500	27.0	62.5	74.0
21	.28	1.66	.53	.18	Carbortam	1075	177300	129400	15.0	33.7	35.0
22	.26	1.47	.49	.04	Carbortam	1075	100000	115200	21.5	56.8	57.0
22	.26	1.47	.49	.04	Carbortam	1000	106000	122000	18.5	56.1	Not Determined

well C hardness below 40 the molybdenum steels are stronger though less ductile. The results after tempering at 600 deg. F. also suggest that the boron-alloy treatment hardly equals as much as 0.29 per cent Mo in strengthening effect even at the lower tempering temperatures. But in toughness or notched-bar impact value the Bortam and Carbortam treatments give a definite superiority. Steel No. 19, treated with the special boron-zirconium alloy with no titanium, shows no superiority in toughness over the molybdenum steels, so that the advantage of using titanium with boron is again apparent.

Cast Manganese-Molybdenum Steel

Alloy steel of equivalent hardenability and physical properties after quenching and tempering at low temperatures can evidently be made by using the boron-alloy treatment instead of about 0.20 to 0.25 per cent Mo, but to duplicate the strength of the molybdenum steel after tempering at 900 deg. F. or higher, the boron-treated non-molybdenum steel should be tempered somewhat less. Under all conditions, however, superior toughness is attained by the quenched and tempered boron-alloy treated steels.

A practical demonstration of these comparisons in steel made on a commercial scale was afforded by a recent trial of Carbortam in manganese-molybdenum steel at a large open hearth steel foundry. This steel was normally made with about 0.28 C, 1.6 Mn, and 0.3 per cent Mo, and the castings were quenched in water from 1650 deg. F. and tempered at 1200 deg. F. Two special heats were made, using 5 lbs. of Carbortam per ton after the regular aluminum deoxidation, one of them without any molybdenum added, and the other with only half the usual amount. The one without molybdenum, however came abnormally low in manganese. Cast test-specimens were rough-machined about 1 in. round before quenching.

Hardenability curves of these steels are shown in Fig. 5, and their compositions and properties after various tempering treatments are given in Table 5. Both of these Carbortam-treated heats were found to contain 0.001 per cent B by a spectrographic comparison against well established standards in a steel-plant laboratory.

The results reported in Table 5 and Fig. 5 show

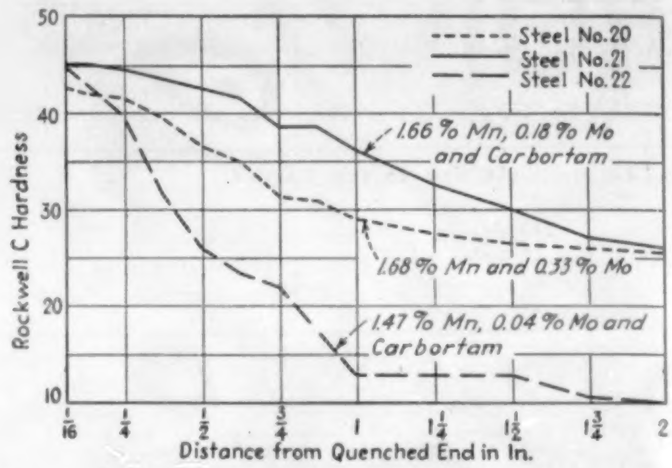

Fig. 5. Hardness distribution along sides of end-quenched specimens of the cast manganese-molybdenum steels described in Table 5.

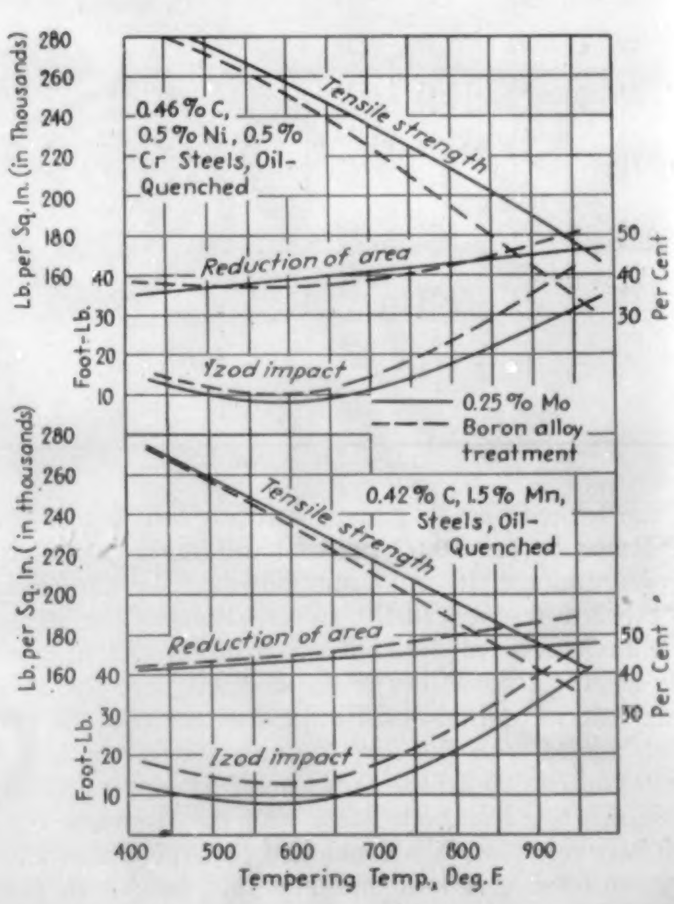

Fig. 6. Variation of some properties of quenched molybdenum and boron-alloy treated steels, respectively, with different tempering temperatures.

that about half the molybdenum in steel No. 20 became unnecessary and could be omitted with even better hardenability and no change in tensile or impact properties after quenching and tempering at 1200 deg. F., provided the steel was treated with Carbortam like No. 21. Steel No. 22 was unfortunately hardly comparable with the others on the basis of hardenability because of its lower manganese content, but its tensile and impact properties were even better, with *all* the molybdenum addition replaced by the Carbortam treatment, than in the 0.33 per cent Mo steel, when the tempering temperature was reduced merely from 1200 to 1075 deg. F. Obviously a very important saving in molybdenum, and in economy, can be effected safely by these simple changes. All three of these steels withstood a special service test in an entirely satisfactory manner.

Influence of Tempering Temperature

A comparison of the effect of the tempering temperature on some of the properties of these steels containing molybdenum vs. the boron-alloy treatment is given in Fig. 6. From this chart the reduction in tempering temperature required for maintaining the tensile strength without molybdenum but with the boron-alloy treatment instead can be estimated. The impact resistance of the boron-alloy treated steel tempered at the lower temperature would evidently be at least as good, if not better than that of the molybdenum steel of equal strength. This chart shows that the boron alloys had a slightly better effect on the higher manganese steel than on the nickel-chromium steel. The values plotted on Fig. 6 were obtained with test specimens of the usual small size, all of which probably hardened quite completely when quenched.

Conclusions

Some of the conclusions that may be drawn from this work are as follows:

1. Treatment of medium-carbon steels with effective amounts of Bortam and Carbortam increases the hardenability or depth of hardening about as much as raising the manganese content 0.7 per cent above the usual value, or raising the silicon content 1.6 per cent above its usual value, or adding 0.20 to 0.25 per cent Mo; but with cooling rates giving Rockwell hardness below about 40 C, the molybdenum steels are generally slightly harder.

2. When the tensile and impact properties are compared after quenching and tempering at temperatures not over 600 deg. F., the boron-alloy treated steels are practically as strong as similar untreated steels with about 0.25 per cent Mo, and are tougher and at least as ductile; but when compared after quenching and tempering at 900 deg. F., the molybdenum steels are appreciably stronger though still less ductile and tough.

3. For equivalent strength, therefore, a slightly lower tempering temperature may be required when boron-alloy treated steels are substituted for molybdenum steels, but the former will then have at least as much, or better, resistance to impact.

4. More consistent agreement in hardenability has been found between individual heats of steel when the boron-alloy treatment was used, than between different heats of untreated molybdenum steel, so that the treatment evidently tends to promote uniformity.

5. The use of titanium rather than zirconium with boron is found to be advantageous, in the form of either a high-carbon titanium-boron alloy (Carbortam) or a more complex low-carbon alloy (Bortam). A similar boron alloy with zirconium instead of titanium was found slightly less uniformly effective in promoting hardenability and toughness of the hardened steel.

The above conclusions are based on tests of steel melted on a laboratory scale and poured in small ingots, but it has also been found in commercial open-hearth heats of cast manganese-molybdenum steel that only 0.001 per cent B acquired from Carbortam treatment gave the same properties after quenching and tempering, and even better hardenability with only 0.18 per cent Mo as with 0.33 per cent Mo without the boron. Although 0.001 per cent B was not found to be sufficient to give the same hardenability with a decrease of 0.29 per cent in the molybdenum content together with a deficiency of 0.21 per cent in manganese, the tensile and impact properties of the quenched boron-alloy treated, non-molybdenum, lower-manganese steel were even better than those of the 0.33 per cent Mo steel after tempering the former at a slightly lower temperature than the latter. Generally the use of sufficient Carbortam or Bortam to give about 0.002 per cent residual boron in the steel is recommended.

Acknowledgments

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[2] "Saving Alloys in Steel by Using Addition Agents; What Alloys Can Be Saved," by W. Crafts, *Metal Progress*, Vol. 42, Dec. 1942, page 1063.

[3] "Saving Alloys in Steel by Using Addition Agents; What Types of Steel Can Be Benefited," by A. W. Demmler. *Metal Progress*, Vol. 42, Dec. 1942, page 1065.

[4] "Boron Steels Increasingly Favored," by N. F. Tisdale. *Iron Age*, Vol. 151, Feb. 4, 1943, page 40.

[5] "Report on Special Alloy Addition Agents," by a special committee of the American Iron and Steel Institute. Contributions to the Metallurgy of Steel, No. 9, Nov. 1942.

(Editorials continued from page 959)

equipment and (2), a competent operator for this equipment. A grinding machine used as its designer intended, and in the hands of a qualified operator will not produce the generally dangerous effects described by the author.

The large number of vital parts manufactured for use in aircraft and ordnance matériel and finished by grinding after hardening proves that grinding is not inherently a dangerous, or even a questionable process. The inspection methods now used are so searching and thorough that, if such were the case, the number of rejections would be enormous, or the service failures would be equally numerous. At the present high level of production, the number of high speed steel cutting tools ground and reground daily reaches figures of astronomical proportions.

It would seem, then, in the face of widespread and satisfactory use of the precision grinding of hardened parts to very close tolerances and high degrees of surface finish, that the author's conclusions should not be interpreted too literally. Using the appropriate equipment and operating under adequate process specifications, grinding is unexcelled as a high production precision finishing method. —R.S.B., Jr.

Strategic Materials in the Future

The war is exhausting the world's natural resources at an alarming rate, and what most concerns us is the prodigal consumption of United States' wealth. What goes into the hopper of war manufacture is by no means inexhaustible. Fortunately, metals can be partially recovered in form of scrap, but fuels such as oil and coal have only a prime—no secondary—consumption.

Even before the present war copper ores had become progressively leaner, as observed in tables in the "Minerals Yearbook" of the Bureau of Mines. Thus average yields for the country as a whole from 1935 to 1939 inclusive were 1.89, 1.54, 1.29, 1.34 and 1.25 per cent. Some say supplies of bauxite may be used up in three years. Some experts predict that the great Mesabi iron ore range may be exhausted by 1950. Lead, zinc and mercury are among the critically diminishing metals. In 1942, output of oil was greater than reserves discovered and considerable concern over future supplies has been expressed of late.

Three courses of action are open for us: To develop our low grade ores, accumulate stock piles for emergencies, or cultivate and guard supplies of strategic resources outside our borders.

Despite nearly four years of war, Germany's steels and metals equipment seem just as rich in alloys and critical materials as at the start of the war, judging by captured weapons and what leaks through our own military secrecy. Apparently Germany has depended almost entirely on tremendous stockpiles.

A nation like Britain, on the other hand, with her rich colonies and powerful Navy can depend largely on sources of supply elsewhere than on the British Isles. Yet such sources may not always prove available, as we have learned to our sorrow through Japan's grab of the world's best tin, rubber and quinine.

Probably the wisest course for the future is not to depend entirely on any one theory of supply. Right now we are apparently emphasizing the bringing in of foreign materials where possible, partly because it suits economy and expediency. Returning empty transports stop at foreign ports and pick up strategic metals and materials, which is better than producing our own ingot metals from lean ores.

If too much dependence is given to foreign sources, we tend to leave undiscovered and undeveloped our local resources. Apparently our best course for the future is to balance properly our imports and home pioneering. It may be necessary to subsidize our home mining companies (as is now being done to copper to some extent).

Coupled with this policy may be a restriction on selling of war materials to potential enemies. The shipping of steel scrap and copper to Japan may not have been a total and calamitous mistake—if, from it, we have learned a lesson for the future.

Finally, if peace plans call for making available world's resources to all nations, let us not entirely forget our own best interest. We were too generous and trusting in pre-Pearl Harbor days.

—H. A. K.

A Comparison of Welding Processes

Type of Process		Characteristics	Treatment Before Welding	Treatment After Welding	Type of Equipment
Gas Welding	Oxyhydrogen	Welding low melting point materials such as lead, aluminum sheets, etc.	Clean surfaces to be joined.	Remove flux, snag and polish weld.	Equipment is portable if compressed gases are used.
	Oxyacetylene	Welding steel and many non-ferrous metals; brazing, flame cutting, flame hardening, etc. Automatic equipment may be used for welding sheet stock to form steel tubing. This is the most widely used gas process. Flame can be varied to be carburizing, neutral or oxidizing, depending on material being welded.	Clean surfaces to be joined.	Remove flux, snag and polish weld.	Equipment is portable or stationary, depending on size of installation. Manual and automatic equipment is used for welding, flame cutting and hardening.
Resistance Welding	Upset Butt	Limited to use in small wireworking plants.	Machine ends to be joined for smooth contact.	Remove large upset area. (Grind or polish).	Not generally portable. Both hand and automatically operated machines are used.
	Flash Butt	Used for joining sheets to form strip, and to weld circled strips and bars to form rings, and for joining sections of pipe or tubing. Dissimilar metals can be welded. Used for high production operations where speed and low cost of operations are important.	No special pre-treatment needed.	Remove flash extrusion and spatter. (Grind and polish).	Not generally portable. Both manual and automatic high production machines are used, the automatic for steel tubing.
	Spot	Has a wide range of applications (in both the shop and in high production industries) in the joining of sheet stock. Portable machines have a capacity of No. 30 gage to 1/8" in thickness; the standard machines will accommodate sheets varying from No. 30 gage to 1" in thickness. Most metals and alloys can be spot welded. Some coated steels can be spot welded.	Sheets must be very clean.	None	Both portable and stationary, hand and automatically operated machines are available.
	Seam	A fast, high production method for joining sheet stock; straight and circular pressure tight welds can be made at speeds of over 100" per min. Some coated steels, carbon, low and high alloy steels, some copper, magnesium, nickel and aluminum alloys are weldable. Range of sheets weldable: No. 22 to No. 11 ga. (0.031-0.125").	Sheets must be very clean.	None	Equipment is not portable; the control is large, expensive and delicate. Suitable for high production joining of sheets.
Arc Welding	DC Carbon Arc	For automatic and specialized applications (automatic welding of aluminum alloys). Also used for arc cutting (dismantling steel structures, etc.). Automatic machinery for welding heavy gage sheet steel to make tubing, also used for welding some light gage tubing.	None	Removal of spatter is usually unnecessary.	Usually the equipment is stationary; arc cutting equipment may be portable especially if gas or diesel motors are used to drive the generator.
	DC Metal Arc	The most commonly used welding process is the shielded metal arc; used for welding most metals and alloys when the correct choice of welding rod and of polarity is made. Nonferrous electrodes that do not give good results with an AC arc can be used. Automatic equipment is used for welding light gage sheet steel to make tubing. This type of equipment is not generally used for welding in restricted areas, or in vertical or overhead positions.	None	Snag and polish weld.	Manual equipment is portable. Both single and multiple operator units, and automatic equipment are used.
	AC Metal Arc	This type of welding equipment is used for about 10% of arc welding jobs. Welds in restricted areas or in overhead or vertical positions may be made. Higher currents can be used than is possible with DC arcs, permitting thicker material to be welded. Not suitable for welding with aluminum, copper alloy, nickel, Inconel, Monel or bare steel rods. Lower no-load losses than DC machines.	None	Snag and polish weld.	Portable or stationary, single or multiple operator units are available. Transformers may be used as a source of welding current (thus increasing efficiency and decreasing upkeep over motor-generator units).
	Atomic Hydrogen AC Arc	Used in specialized applications where other types of welding equipment are not suitable. Automatic equipment is used for welding stainless sheets for tubing. Used for high-speed, high-Ni and high-Cr steels and light gage sheets. The operating costs are higher than those of the other common welding processes.	None	Grind and polish weld.	Manual equipment is portable. Automatic equipment for machine welding is stationary.

Compiled by Robert S. Burpo, Jr.

HIGH PRESSURE CONTAINERS

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Kidde cylinders are available in many sizes and shapes for the storage of carbon dioxide and other gases. Special-purpose valves and release mechanisms have been devised by Kidde engineers.

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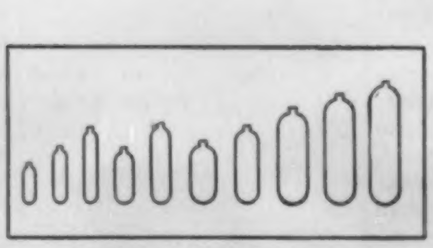
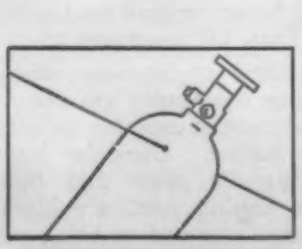
Walter Kidde & Company, Inc.
531 Main Street **Belleville, N. J.**

LIGHTER WEIGHTS



WIDE RANGE OF SIZES



SHATTER-PROOF

PROTECTS LIVES

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HIGH PRESSURE GASES • FIRE PROTECTION

NUMBER 11

MATERIALS AND DESIGN
Copper Alloys

We begin in this issue the publication of a comprehensive tabulation of the common coppers and copper alloys, with reference information on types, names, specifications, forms, compositions, and characteristics. The first two sections, appearing in this issue, are as follows:

Subject	*"File Facts" Numbers*	*Title*
Coppers with a minimum of 99.20% Cu, (Ag being counted as Cu)	11	Commercial Coppers
Copper-zinc alloys with a maximum of 0.50% Pb and having no other impurity or alloying agent in excess of 1%	12	Brasses

The specifications of the other commercially important copper alloys — leaded brasses, bronzes, silicon coppers, phosphor coppers, copper beryllium alloys, aluminum bronzes, etc. — will be presented in future "File Facts" pages.
This information was obtained from the ASTM Standards, 1942, and from The SAE Handbook, 1942 edition.

Commercial Coppers

A Digest of Common Specifications

Grade Specifications

Name	Forms	Specification No.	Composition, %	Characteristics
Oxygen-free copper	Wire bars, billets and cakes	ASTM B170	Cu + Ag, (min.), 99.92	High thermal and electrical conductivity; corrosion resistant and very ductile; also used where resistance to hydrogen embrittlement or to fatigue are important.
Lake tough pitch copper	Wire bars, cakes, slabs, billets, ingots and ingot bars	ASTM B4	Low-resistance lake: Cu + Ag, 99.900 High-resistance lake: Cu + Ag + As, 99.900	Low-resistance lake copper has about the same electrical properties as electrolytic tough pitch copper. High resistance lake copper has lower conductivity and greater strength than low resistance lake.
Electrolytic tough pitch copper	Wire bars, cakes, slabs, billets, ingots and ingot bars	ASTM B5	Cu, 99.900	Most widely used form of copper; resistant to corrosion, can be easily formed, hot and cold worked, has good electrical properties and fatigue resistance; susceptible to embrittlement when heated in a reducing atmosphere.
Electrolytic cathode copper	Cathode copper	ASTM B115	Cu + Ag, 99.90	Has the same resistivity as ASTM B4 and B5 wire bar coppers.
Deoxidized copper	Fire - refined copper other than lake	ASTM B72	Cu + Ag, 99.7000 As, (max.), 0.1000	Not suitable for electrical purposes nor for further alloying; it is usually rolled into sheets and shapes for mechanical purposes.

Form Specifications

Forms	Specification	Types	Composition, % Cu+Ag (min.)	P (max.)	As
Seamless condenser tubes and ferrule stock	ASTM B111, copper	Copper	99.90	0.035	
	ASTM B111, arsenical copper	Arsenical copper	99.20		0.015-0.75
	SAE 75	Copper tubing	99.90		
Forging rods, bars and shapes	ASTM B124	Alloy No. 12	99.90		
Sheet, strip and plate	ASTM B152	A—Electrolytic tough pitch copper	99.90		
		B—Phosphorized copper, high residual phosphorus	99.90	0.015-0.04	
		C—Oxygen-free copper, without residual metallic deoxidants	99.90		
		D1—Silver-bearing copper, tough pitch	99.90		
		D2—Silver-bearing copper, phosphorized	99.90	0.04	
		D3—Silver-bearing copper, oxygen-free	99.90		
		E—Arsenical tough pitch copper	99.95		0.015-0.50
	SAE 71	Copper sheet	99.90		

Compiled by Robert S. Burpo, Jr.

Engineering File Facts

BRASSES

A Digest of Common Specifications

Name	Characteristics	Specifications	Form or Grade	Composition, % Cu	Pb, max.	Fe, max.	Zn	Others
Gilding metal (95-5)	Good cold and hot working properties	ASTM B36, Alloy #1	Brass sheet and strip	94.0-96.0	0.03	0.05	Rem.	——
		ASTM B134, Alloy #1	Brass wire	94.0-96.0	0.05	0.05	"	——
Commercial bronze (90-10)	Excellent hot and cold working properties; corrosion resistance equal to that of copper	ASTM B36, Alloy #2	Brass sheet and strip	89.0-91.0	0.05	0.05	"	——
		ASTM B130	Gilding metal sheet and strip	89.0-91.0	0.03	0.05	"	0.125*
		ASTM B131	Gilding metal bullet jacket cups	89.0-91.0	0.03	0.05	"	——
		ASTM B134, Alloy #2	Brass wire	89.0-92.0	0.05	0.05	"	——
Red Brass (85-15)	Excellent cold working qualities; has greater corrosion resistance than copper and similar hot working properties; relatively free from season cracking and "dezincification"	ASTM B36, Alloy #3	Brass sheet and strip	84.0-86.0	0.05	0.05	"	——
		ASTM B43, Red brass	Brass pipe	83.0-86.0	0.06	0.05	"	Sn 0.15 max.
		ASTM B111, Red bras	Copper and copper alloy seamless condenser tubes and ferrule stock	84.0 min.	0.075	0.06	"	——
		ASTM B134, Alloy #3	Brass wire	84.0-86.0	0.05	0.05	"	——
		ASTM B135, Alloy #1	Miscl. brass tubes	83.0-86.0	0.06	0.05	"	——
		SAE 44	Cast brass to be brazed	83.0-86.0	0.05	0.15	14.0-17.0	——
		SAE 74, Red brass	Annealed seamless brass tubing	84.0-87.0	0.06	0.05	Rem.	——
		SAE 79, Grade A	Red brass sheet	84.0-86.0	0.05	0.05	"	——
Low brass (80-20)	Closely resembles 85-15 alloy in many of its properties; hot working operations are satisfactory only when closely controlled and when the Pb content is less than 0.05%; corrosion resistance is good and resistance to season cracking and "dezincification" is slightly lower	ASTM B36, Alloy #4	Brass sheet and strip	79.0-81.0	0.05	0.05	"	——
		ASTM B134, Alloy #4	Brass wire	79.0-81.0	0.05	0.05	"	——
		SAE 79, Grade B	Red brass sheet	79.0-81.0	0.05	0.05	"	——
Cartridge brass (70-30)	Best combination of strength and ductility of all Cu-Zn alloys; has excellent cold working properties and if the Pb content is below 0.05%, it has fair hot working qualities; good resistance to corrosion	ASTM B14	Seamless brass boiler tubes	69.0 min.	0.05	0.10	"	0.50*
		ASTM B19	Cartridge brass sheet, strip and discs	68.5-71.5	0.05	0.05	"	0.150*
		ASTM B36, Alloy #6	Brass sheet and strip	68.5-71.5	0.05	0.05	"	——
		ASTM B129	Cartridge brass-cartridge case cups	68.5-71.5	0.05	0.05	"	0.150*
		ASTM B134, Alloy #5	Brass wire	71.0-73.0	0.05	0.05	"	——
		ASTM B134, Alloy #6	Brass wire	68.5-71.5	0.05	0.05	"	——
		ASTM B135, Alloy #2	Miscl. brass tubes	68.5-71.5	0.06	0.05	"	——
		SAE 70, Grade A	Commercial brass sheet	68.5-71.5	0.05	0.05	"	——
		SAE 80, Grade A	Brass wire	70.0-74.0	0.10	0.06	"	——

(Continued on page 993)

NUMBER 12 (continued)

BRASSES

A Digest of Common Specifications

Name	Characteristics	Specifications	Form or Grade	Composition, % Cu	Pb, max.	Fe, max.	Zn	Others
High brass (commercial brass, 66-34, or 2 and 1)	The alloys in this group contain 64 to 68% copper; those with higher copper content (ca 68%) are suitable for spinning and deep drawing; the 64% copper alloys have good cold working properties in general; corrosion resistance is slightly less than that of 70-30 alloys	ASTM B36, Alloy #7	Brass sheet and strip	66.0-69.0	0.07	0.05	"	——
		ASTM B36, Alloy #8	Brass sheet and strip	64.0-67.5	0.30	0.05	"	——
		ASTM B43, high brass	Brass pipe	65.0-68.0	0.80	0.07	"	——
		ASTM B134, Alloy #7	Brass wire	64.0-67.5	0.10	0.05	"	——
		ASTM B135, Alloy #3	Miscl. brass tubes	65.0-68.0	0.30-0.80	0.07	"	——
		SAE 70, Grade B	Commercial brass sheet	66.0-69.0	0.07	0.04	"	——
		SAE 70, Grade C	Commercial brass sheet	64.5-67.5	0.03	0.05	"	——
		SAE 74, High brass	Annealed seamless brass tubing	65.0-68.0	0.80	0.07	"	——
		SAE 80, Grade B	Brass wire	64.0-68.0	0.10	0.07	"	——
Muntz Metal (Naval brass, 60-40)	Has fair corrosion resistance combined with high strength and moderate ductility; has good cold and excellent hot working qualities; it is a relatively inexpensive alloy	ASTM B21, Grade A	Naval brass rods	59.0-62.0	0.20	0.10	"	Sn 0.5-1.0
		ASTM B21, Grade B	Naval brass rods	59.0-62.0	0.4-1.0	0.10	"	Sn 0.5-1.0
		ASTM B43, Muntz metal	Brass pipe	59.0-63.0	0.50	0.07	"	Sn 0.15 max.
		ASTM B111, Muntz metal	Copper and copper-alloy seamless condenser tubes and ferrule stock	59.0-63.0	0.3	0.07	"	——
		ASTM B124, Alloy #1	Copper-base alloy forging rods, bars and shapes	58.5-61.5	0.20	0.15	"	——
		ASTM B124, Alloy #3	Copper-base alloy forging rods, bars and shapes	59-61	0.20	0.10	"	Sn 0.5-1.0
		ASTM B135, Alloy #5	Miscl. brass tubes	59.0-63.0	0.80	0.07	"	——
		ASTM B171, Muntz metal	Copper alloy condenser tube plates	58.0-61.0	0.35-0.90	0.15	"	Sn 0.25 max.
		ASTM B171, Naval brass	Copper alloy condenser tube plates	59.0-61.0	0.20	0.10	"	Sn 0.50-1.00
		SAE 73	Naval brass rod	59.0-62.0	0.20	0.10	"	Sn 0.50-1.50
		SAE 74, Muntz metal	Annealed seamless brass tubing	59.0-63.0	0.50	0.07	"	——
		SAE 76, Muntz metal	Naval brass tubing	59.0-61.0	0.30	0.10	"	Sn 0.50-1.50
		SAE 82, Muntz metal	Brass wire	59.0-62.0	0.30	0.06	"	——

**Maximum total of elements other than copper and zinc, per cent*

Compiled by Robert S. Burpo, Jr.

METALLURGICAL ENGINEERING

shop notes

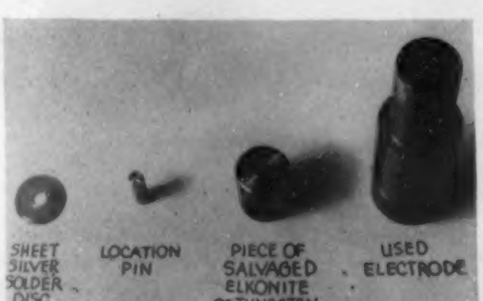
Salvaging of Tungsten Electrodes

by Thomas F. Flynn,
RCA Victor Div.,
Radio Corp. of America

Tungsten-copper and cemented tungsten are in common use for the contact tips of welding electrodes, particularly for resistance welding. Tungsten is a critical war material, and is high in cost.

It has been common practice to discard electrode tips after they were partially worn down. In the tube plant of the RCA Mfg. Co., a procedure has been developed whereby tungsten electrode tips, regardless of their shape or size, can be salvaged with a minimum of cost and a maximum of saving in dollars and material by assembling discarded tips with the use of silver solder or brazing material.

The process is as follows: In the case of cemented tungsten-copper electrodes, the tips are removed from the tip holders and are cleaned to bright metal. The accompanying photograph illustrates the subsequent steps. Holes are drilled in the discarded tips to take a copper aligning plug. This plug, which fits the hole with .003 in. clearance, locates the tips for assembly. The surfaces of the tips to be joined are well fluxed, and a piece of



.005 in. sheet silver solder is sandwiched between them. The temperature of the parts is then brought up slowly to the point where the silver solder flows freely. At this stage, the parts are rotated and pressed together lightly to insure a good bond between the tips and the elimination of flux pockets.

With pure tungsten tips, the surfaces to be joined are given a light coating of copper before the silver soldering operation, to insure a solid bond. The method illustrated utilizes an aligning plug. A wide variety of methods for locating parts during assembly may be required for different jobs, but these should not present difficult problems, since the process is readily adaptable to them.

For assemblies where it is desired to add additional material to a worn-out tip without disturbing the tip in its holder, the second joint is made by utilizing a silver solder that melts at a lower temperature than the solder between the original tip and its holder.

Before this assembly process was worked out in our tube plant, approximately 50 per cent of tip material was discarded. Today, we are utilizing 100 per cent of the material. Aside from the saving of critical material, the financial saving runs into thousands of dollars a year.

[The author was awarded a Certificate of Individual Production Merit by the War Production Board for this idea—Editor.]

Outside Weld and Grinding Eliminated

By Thomas Born,
White Motor Co., Cleveland

Jobs are often done the hard way just because they were first started that way and without anyone subsequently giving further thought to improving or simplifying the method. Often the improvement is a simple one with the remark made: "Why didn't somebody think of this before?"

Such was the case with a sheet metal fabricated part in the plant where I work. As shown in the accompanying photograph of the author and his idea, the parts were formerly welded together, both inside and outside along the white line. I decided to eliminate the outside weld, which at the same time made unnecessary

a grinding operation. The part was as sound and serviceable as before. But the eliminations saved about 300 man-hours a month.

[The author was awarded a Certificate of Production Merit by the War Production Board for this idea.—Editor.]

A thorough understanding of grinding wheels on the part of the production engineer often pays big dividends. A large automobile plant, changing its camshafts from a steel forging to an iron casting, changed three of the specifications of the grinding wheel and produced camshafts having the same finish, same accuracy and same high quality, though the material was radically different.

—"Grits and Grinds," Norton Company

Steel mills, usually having neither time nor facilities for sorting scrap, dump it into furnaces as it comes to them. As a result, some shipments of ordinary steel contain more nickel than the so-called nickel-steel alloys. Thus, gear engineers are often receiving alloy steel that they tried to conserve through the use of heat treated carbon steel. More and more is spectroscopic analysis being used on every new batch of steel received. It identifies the spectral lines of every element present in an unknown substance and permits classification of the steels for proper heat treatment.

—Westinghouse Electric & Mfg. Co.

Scarfing Done by Hand or Machine

by E. A. Doyle
Linde Air Products Co.

Surface imperfections on steel billets and slabs are removed quickly by the oxyacetylene flame. This operation, known as steel conditioning or scarfing, can be

accomplished manually after the steel has cooled, as shown in the top photograph.

Scarfing can also be done by a conditioning machine set into the rolling-mill line, which scarfs the steel while it is

still hot and without interrupting the rolling operation. The machine in the lower photograph is removing simultaneously 1/16 in. of steel from all four sides of an 8-in. square billet at a speed of 125 ft. per minute.

Ode* to an Electrode

by W. F. Schaphorst,
45 Academy St.,
Newark, N. J.

I'm just an electrode, I humbly admit,
But, nevertheless, I am doing my bit;
Good welders rely on my strength and my grip
For safeguarding cannon, tank, airplane, and ship.
Without me you never will get anywhere,
So please, Mister Welder, do treat me with care.
In storage insist that I'm always kept dry,
Off the damp floor on a shelf amply high.
Beware sweating pipes, open windows, and such,
I sometimes am rusted by H_2O's touch.
Then, if through some mishap I chance to get wet,
Just spread me out quickly. And please don't forget
That I do my best work when I am not bent;
And fit all joints properly 'ere you consent
To do any welding, and then for best strength
Make legs of all fillet welds equal in length,
And, too, make the face of all fillet welds flat.
Since I'm growing scarcer, it's now urgent that
To win in this conflict with gun, plane, and sub,
You use me clear down to the tiniest stub.
Produce everlastingly with me — don't cease —
And we'll win the war, and the right kind of peace.

* Ode: the same thoughtful treatment is *owed* to an electrode as to any good friend.
—Editor.

Much has been written on how best to put to use welding electrode stubs. Perhaps one of the most novel is to give them to welding schools for practice work. A member of the New York Board of Education and a certain manufacturer got together by accident and evolved the idea. The manufacturer explained that in a certain production job it is impossible to use more than 8-in. of a 14-in. electrode. Material to be welded is placed on a revolving, mechanically-driven fixture and, because of automatic and continuous nature, it is always most economical to start each routine with new electrodes. "Orphan" stubs are best given away.

—General Electric Co.

Avoiding Quench-Cracking

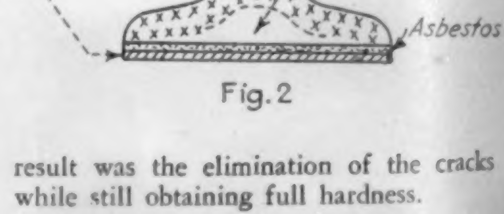
by William P. Matthew,
A. O. G. Corporation

In the manufacture of trigger handles for a small anti-aircraft cannon even with best results, a 6 per cent crack failure resulted in an interrupted water quench. The Rockwell specification was C-47-53 on thin and thick sections. The triggers are made of plain carbon steel forging, with .48 carbon. An appalling loss due to cracking was being experienced.

Almost every known quenching medium was tried, but results were always the same — either uniform Rockwells were obtained along with some cracks, or the cracks were eliminated at the expense of uniform hardness. The crack always occurred in back of a webbed section on the handle.

It was reasoned, therefore, that in quenching the last place to harden, hence the last place to expand when the rest of the metal was contracting, was in the center of the web, which is indicated in Fig. 1.

The solution lay in bringing this last point of expansion to the surface where strains could expend themselves in the open without setting up a crack from the interior to the surface as an avenue of escape. This was done simply by placing an asbestos sheet over the back of the web. (Fig. 2), held in place by a thin metal sheet wired to the handle. The



result was the elimination of the cracks while still obtaining full hardness.

Sharp exposed wire rope ends are extremely hazardous. A simple remedy is to braze the end of the rope with a bronze welding rod, running it back an inch or two from the end. Done properly, it covers all the wire ends and holds the rope intact so that seizings can be removed.

—F. L. Spangler,
American Society for Safety Engineers

Metallurgical Engineering Digest

A Digest of Important Developments in the World of Metals

1 Metal Production

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric Furnace Melting Practice, Equipment and Refractories. Melting and Manufacture of Non Ferrous Metals and Alloys. Soaking Pits and Other Steel-Mill and Non-Ferrous Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill, Pickling and Heavy Forging Practice.

2 Foundry Practice

Melting and Pouring of Gray Iron, Malleable, Steel, Brass and Bronze, Aluminum and Magnesium Castings. Molding, Core-Making, Gating and Risering, etc. Foundry Furnaces, Refractories, Ovens, Molds, Sands, Binders, Auxiliary Equipment and Materials.

3 Metal-Working and Treating

Die Casting. Powder Metallurgy. Drop, Hammer and Upset Forging. Press-Forming, Drawing, Extruding and Stamping. Machining, Grinding and Polishing. Hardening, Tempering, Age-Hardening, Annealing and Malleableizing. Carburizing, Nitriding and Surface Hardening, Heating Furnaces, Refractories, Fuels and Auxiliaries. Welding, Flame-Cutting, Hardfacing, Brazing, Soldering and Riveting. Cleaning, Pickling, Degreasing and Sandblasting. Electroplating, Anodizing, Galvanizing, Metal-Spraying, Coloring, Buffing and Organic Finishing.

4 Materials and Engineering Design

Engineering Properties of Metals and Alloys. Resistance to Corrosion, Wear, Fatigue, Creep, etc. Engineering Design Problems of Specific Industries and Products. Selection of Metals, Metal-Forms and Fabricating Methods. Non-Metallics in the Metal Industries. Applications of Individual Materials. Conservation and Substitution.

5 Testing, Inspection and Control

Specifications. Physical and Mechanical Property Testing and Inspection. Routine Control and Instrumentation. Radiography and Magnetic Inspection, Spectrographic and Photoelastic Analysis. Corrosion- and Wear-Testing. Examination of Coatings. Surface Measurements. Metallographic Inspection and Technique.

1 Metal Production

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining • Open-Hearth, Bessemer, Electric Furnace Melting Practice, Equipment and Refractories • Melting and Manufacture of Non Ferrous Metals and Alloys • Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces • Steel and Non-Ferrous Rolling, Wire Mill, Pickling and Heavy Forging Practice

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Silica Refractories

Condensed from "The Iron Age"

Raw material for silica brick is usually 96 to 98 per cent silica. Lime is normally added as a bond, varying between 1 and 2.5 per cent. The effect of lime on the melting point of silica is peculiar in that a replacement of almost 30 per cent of the silica results in only a small drop in melting point. This is attributed to the fact that lime and silica form two liquids that are immiscible. This is not true of certain other oxides. Hence if lime is used as a bond, quartzite should not be high in alumina or alkalies.

In the reaction between silica and iron oxide there is immiscibility and only a small drop in melting point, even with 40 per cent substitution by iron oxide. This is important since otherwise silica refractories would be rapidly slagged away by the iron oxide in the furnace atmosphere. In actual practice, the iron in contact with the silica is by no means all in the ferrous state but the same tendencies are present even in the ternary system SiO_2-FeO-Fe_2O_3.

Sosman suggests that the iron oxide pick-up and its effect on the melting point of a roof limits the safe operating temperature to 3000 deg. F. In many works an operating temperature of 3055 deg. F. is considered quite reasonable.

Reactions of silica with alumina are also of great importance since alumina occurs in the natural rock, while clay is sometimes used as a bond for silica bricks and always as a bond for the so-called ganister, used for patching launders and acid furnace tap holes.

Silica suitable for brick making in the United States is obtained from the Tuscarora in Pa., the Barboo in Wis., and Weiner formations in Ala. The first two are known as eastern and western quartzite. The western bricks have higher thermal conductivity which is attributed to lower porosity.

This difference in porosity raises the point which is clearly brought out by raw materials used in Germany. Until recently German bricks were made from Findlings quartzites which are suitable for making silica brick, whereas American and British quartzites are of coarse crystal size, findlings shows a wide range, including some very fine material. One result is that the Findlings quartzite shows a much more rapid rate of conversion to cristobalite and tridymite.

Quite as important as the crystal size is the porosity before and after firing. The Findlings material showed a porosity of only 0.3 per cent before firing as compared with 1.0 per cent for Welsh quartzite, 4.6 per cent for Sheffield ganister and 13.0 per cent for a bastard ganister. On firing, the advantage of the Findlings material becomes still more obvious.

The difference in the conversion rate as judged from the drop in specific gravity is not striking, but here again Findlings is the best; it drops to 2.41 after 1 hr. at 2640 deg. F.

—J. H. Chesters, *Iron Age*, Vol. 151, Jan. 21, 1943, pp. 36-41.

The relation between slag volume and coke consumption is definite.

Are you taking fullest advantage of this relationship to produce more iron?

The proper application of SOLVAY Dustless Dense SODA ASH will permit lower slag volume with consequent savings, and at the same time keep sulfur well in line.

SOLVAY SALES CORPORATION

Alkalies and Chemical Products Manufactured by The Solvay Process Company

40 RECTOR STREET — NEW YORK, N. Y.

Rolls for Sheet Galvanizing

Condensed from "Steel"

Rolls for sheet galvanizing machines are made from plain and alloy cast-irons and carbon and alloy steels. Steel rolls can be cast or forged.

In one galvanizing machine, the submerged rolls are solid forgings of special steel about 8 in. in diameter when new. Forged steel renewable sleeves protect the necks from the action of the zinc. As the roll surfaces must be kept smooth and true, they must be machined occasionally, taking off about 1/8 in. diameter. With continuous operation under good conditions, rolls are usually machined every 8 months. They can be used until reduced to about 6 in. diameter.

The bottom roll must be not less than 1 in. above the dross line. A worm drive is best for this roll as it causes the least agitation of the bath. The exit rolls remove excess metal, control the weight of the coating, and make it even. Generally, they are similar to the submerged rolls and are maintained similarly. The surfaces have spiral grooves to carry the zinc along the rolls and assist in making the coating uniform. The motion of the exit rolls must be smooth and regular.

Provision is made for changing the relative speeds of the submerged and exit rolls to prevent crowding or pulling the sheets. The bath level is usually kept highest for the heaviest gage sheets, and lowest for light-gage sheets. If allowed to drop too low, dirt, flux, etc., are more likely to collect on them and be rolled into the coating.

An easily removable separating plate of special steel keeps flux and oxide away from the rolls and confines clean zinc around them. Clean galvanized sheet can not be produced without this plate. For smooth and uniform application of the molten zinc, the surface of the roll must be "wet" properly, which can be done only by a zinc-iron alloy. At low temperatures the zinc-iron alloy protects the roll surface from continued drastic attack by the zinc.

With increased temperature, a recrystallization of the zinc-iron alloy occurs, and the protecting alloy formed at low temperatures seems to open up, allowing the zinc to penetrate through to fresh iron below. In addition, the taking up of more iron into the zinc-iron alloy seems to increase greatly its expansive power.

As the groove is already a weak point and all the destructive elements are concentrated there, cracking of the rolls in the grooves is almost certain to result. The cracks usually develop at the bottom of the groove. A U-shaped groove is recommended, as cracking occurs less readily in this case than if the bottom has square corners or is V-shaped.

Causes of Warping

Warping of rolls may result if the internal strains caused by machining are not relieved by proper heat treatment. Warping in the consumer's shop may be caused by mechanical bending through improper removal of the roll from the machine; by

placing a hot roll on a cold floor; by cooling a roll in water after removal from the zinc bath; and by charging a cold roll into the hot bath.

In cleaning the rolls, the temperature should be kept well under 900 deg. F. An ideal method is a long soaking at low temperature. It appears desirable to use high-pressure hot air or dry steam to blow the surface and grooves clean after the metal has been thoroughly softened and melted at the low temperature.

If the rolls are cleaned by pickling, the sulphuric acid should be weak, and a good inhibitor used. This may take 2 to 3 hrs. The temperature of the acid bath should be low, and the roll should not be put into it while at a high temperature. Tin and cadmium are used in sheet galvanizing baths to make the zinc more fluid. A bath in this condition can be operated at lower temperatures than one of pure zinc.

There should be no high concentration of heat in the bottom of the pot, as this produces excessive dross. When this material gets into the grooves, it can crack the roll. High temperatures also favor pitting of the surface.

Rolls should be kept turning continually in the bath when there is a stoppage of production. In case of long shut-downs, it is best to remove the exit rolls from the bath.

—Wallace G. Imhoff, *Steel,* Vol. 112, Jan. 25, 1943, pp. 72-73, 76, 78; Feb. 8, 1943, pp. 88, 90, 112.

Steel Clad With Gilding Metal

Condensed from "The Iron Age"

Originally developed by Superior Steel Corp. as a method for producing a composite steel with an ordinary carbon core and a stainless steel surface, the process is no wused to produce a composite metal, 80 per cent of which is ordinary steel and 20 per cent gilding metal (90% Cu and 10% Zn).

This composite metal is used in the production of 30 and 50 caliber bullet jackets. To comply with large orders for the United States government the Superior Steel Corp. allowed the use of the process without royalties for the duration of the war.

Potential uses for the process during peace time appear sizable, since the composite metal is not limited to steel and gilding metal alone, but can also utilize stainless steel, silver, copper, and other metals.

The process consists of starting out with a special section of ordinary carbon steel. Steel section with the gilding metal facing is given a special treatment to keep the metal together. With gilding facing secured in place it is put in a furnace for heating and afterwards the material is rolled through several passes into a hot-rolled gilding metal clad steel strip. Later it is annealed, pickled, cold-rolled and sheared.

Disks are punched out and cups are made which are later drawn into finished bullet jackets.

—T. C. Campbell, *Iron Age,* Vol. 151, Jan. 14, 1943, pp. 33-34.

Graphite Rod Melting Furnaces

Condensed from "Stahl u. Eisen"

Graphite rod melting furnaces are usually drum furnaces with one or two heating rods, or hearth furnaces with 3 rods, which are heated by low voltage alternating current and transmit their heat practically only by radiation to the charge and the furnace walls. Some of the more usual types are listed in table below.

The heating rods consist of electrographite with a specific resistance of 8-12 ohm per m. per sq. mm. and require, according to dimensions, 20 to 75 volt maximum with up to 6000 amp. (300 amp. per sq. cm.); the radiated energy is about 100 watt per sq. cm. surface at a temperature of 2500 deg. C. (4530 deg. F.). The energy consumption is made up as follows:

Type of furnace	Steel Charge Kg.	Capacity KVA	Graphite Rods No.	length mm.	diam. mm.
	30	60	1	365	30
Drum	100	120	1	765	30
	200	180	1	970	35
	300	200	1	1200	50
Hearth	1000	450	3	1200	50

Capacity in kg.	100-120		1000-1200	
Energy for melting in Kw.	125- 90		450- 400	
Energy for finishing in Kw.	90- 65		360- 250	
Steel, type	A	B	A	B
total energy in kw. hr. per ton	680-720	850-950	680-720	800-900

Type A steel is high alloy steel with 0.7 to 2.0 C, 4 to 20 Cr, 4 to 12 W and 5 to 35 per cent Co. B is a medium alloy steel with 0.2 to 0.6 per cent C. An investigation of the economy of the 1-ton hearth furnace showed that it is practically the same as that of the coreless induction furnace. The drum type furnace is more advantageous than the hearth type with regard to charging and energy cost.

—W. Geller & H. Hönig, *Stahl u. Eisen* Vol. 62, Jan. 1, 1942, pp. 9-14.

Rolling of Copper

Condensed from "Jour. of Applied Mechanics"

The complete strain distribution in rolled bars was studied by rolling copper bars with a varying number of passes in different directions at a 20 per cent reduction per pass. Previous studies published have been made on bars rolled in one direction only. The strain patterns were made visible by coating the bars with a brittle lacquer.

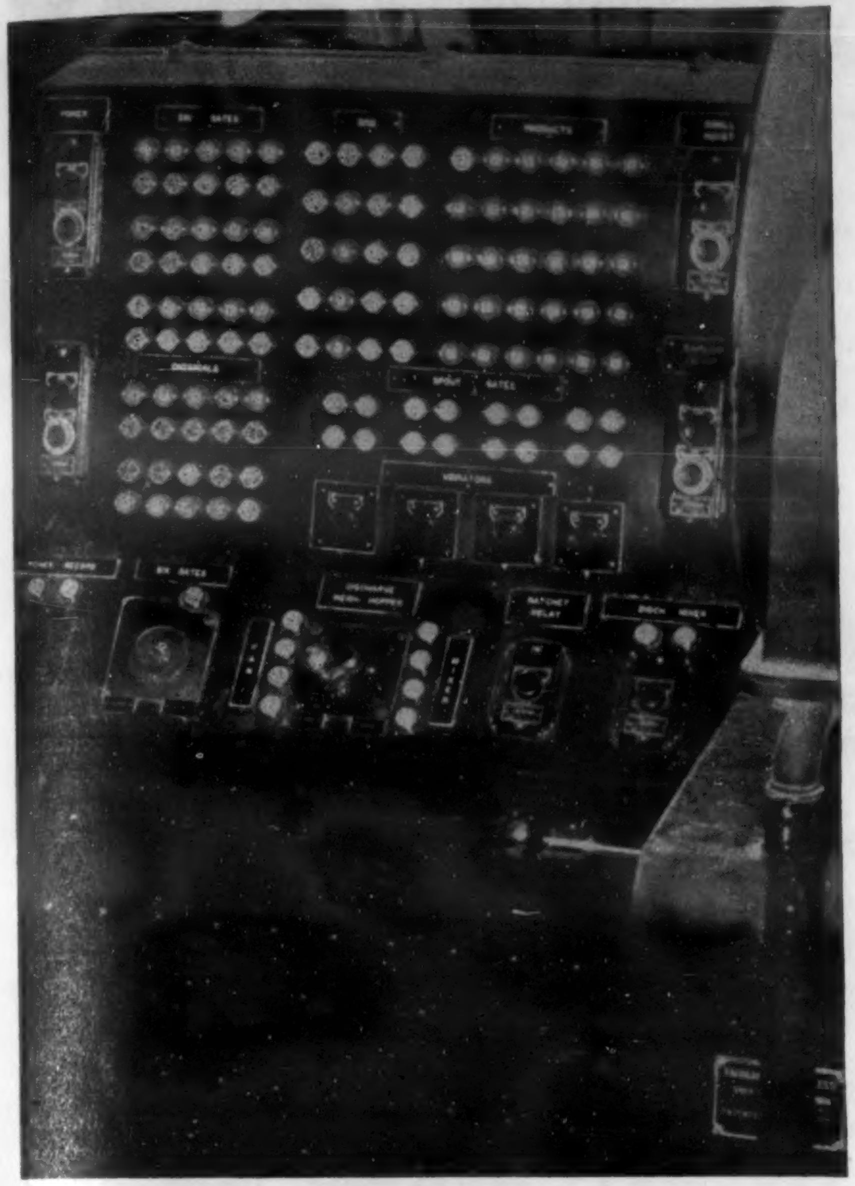
The tests established the fact that alternate passes in different directions produce much less distorted networks, as compared to the cases of rolling in the same direction for each pass. Tensile elastic strains exist ahead of the rolls. Some numerical values are given derived from such tests.

A comparison of lateral compression tests and the rolling experiments demonstrate the presence of similarly directed elastic tensile strains in both cases for some distance from the center lines of the rolls. The network shows that the shearing strains were always the greatest in the outside fibers of the bars when they were rolled in the same direction with a number of reductions.

On the other hand, the shearing strains were greatest inside the bar when rolling took place in alternately opposed directions. The sequence of the rolling operations does not affect appreciably the magnitudes of the axial, vertical or lateral normal strains, but affects in a very marked manner the shearing strains and the shape of the profiles of the vertical lines marked on the bar.

The alternately opposed directions of rolling produce a much less distorted network with very much smaller shearing strains than does the rolling of the bar in one direction only during the various passes. Formulas to calculate the strains from the network are given. Six references of literature related to the subject are included.

—C. W. MacGregor, & L. Coffin, Jr., *J. Applied Mechanics*, Vol. 10, Mar. 1943, pp. A13-A20.



EXACT CONTROL

★

FOR SURE PERFORMANCE

THE bomber pilot's course is guided by precision instruments. Refractory manufacture, too, must be guided by precision control.

Years of experience in meeting practical problems in the open hearth and electric furnace have shown that refractories best suited for modern steel making cannot be made by rule of thumb methods. They must be designed to meet specific conditions met in the furnace, and they must be manufactured to design...for balanced chemical composition, positive physical characteristics, and uniformity of product.

To insure the desired properties in the manufacture of products where extreme accuracy is essential, Basic Refractories developed and installed a plant built around precision equipment, operating automatically throughout. Key to this equipment is the electric control board shown here.

It provides exact and automatic control of those final, critical stages of a process—proportioning and mixing—which began with the manufacture of synthetic mineral compositions designed to perform specific work. Because these controls are mechanical and automatic, there is no possibility of deviation or error.

Ramix...Hearth Patch...695 Plastic...Gunmix...are typical products of this plant. Their outstanding performance in severe service is familiar to most furnace men. No small part of their continued success is due to the fact that, combining the best of research and practical experience they are made by a process rigidly controlled to insure uniformity and dependable quality.

BASIC HEARTH REFRACTORIES

BASIC REFRACTORIES, INCORPORATED
CLEVELAND, OHIO

PRODUCERS OF MAGNESITE AND DOLOMITE HEARTH MATERIALS FOR STEEL FURNACES

Slag Control Through Blast Furnace Tuyeres

Condensed from "Metals Technology"

The acute shortage of steel scrap necessitates the use of higher percentages of hot metal in the open-hearth charge. The sulphur content of hot metal therefore becomes increasingly important in the control of quality of steel. More than 90 per cent of the sulphur is contained in the coke. With increased demand coke quality has been toward higher sulphur, higher and more variable ash and poorer physical characteristics.

Principles of Iron Desulphurization

1. Iron picks up sulphur until it reaches the tuyere level. The zone is relatively narrow.
2. Combustion of coke is confined to spherical zones extending approximately 40 in. from the nose of each tuyere.
3. With a constant amount of sulphur in the charge, the sulphur content of the metal is a function of hearth temperature, final slag analysis, slag viscosity and slag volume. For a slag of constant analysis, viscosity always decreases with an increase in temperature. An increase in lime generally will increase viscosity and raise the melting point.

Bosh slag differs from the final slag in that it is not diluted by the siliceous oxides in the coke ash and is therefore high in lime and extremely viscous. It probably contains calcium ferrites, which are decomposed with a reaction absorbing heat. Limy bosh slags are not conducive to utilization of uniformly high blast temperatures. It has been suggested that if part of the lime usually charged into the furnace top were blown into the tuyeres, an improved type of bosh slag would be obtained, and thus the desirable high lime final slag required for proper desulphurization.

Coke ash may vary daily as much as 2 per cent above and below the average. Thermal and chemical effects of this may be controlled by variation in blast temperatures and by a constant excess slag volume or frequent adjustments in the amount of limestone and ore burden charged. However, production and coke rate suffer. It is difficult to time limestone additions perfectly. Some operators believe that variations of ash content in low-ash coke have a greater effect on furnace operation than in high-ash.

Lime Introduced Through Tuyeres

It has been shown that if 15 per cent of the normal limestone for a 9 per cent ash coke were introduced through the tuyeres instead of the furnace top, it would be equivalent to a reduction of 100 lbs. of flux per ton of iron. The bosh slag would not vary, because the amount of limestone charged into the furnace top would be constant. The final slag could be held at any desired composition by the injection of various amounts of limestone through the tuyeres. Their uniformity of composition would be limited only by the time required for injection. In practice, burnt lime instead of limestone will be injected since limestone by calcination would probably unduly lower the hearth temperature. This will make additional heat available in the stack and increase the reducing power of the stack gas.

The addition through the tuyeres of 57 lbs. of lime per net ton of iron would be required when using a 9 per cent ash coke at a 15 per cent reduction in limestone charged into the furnace top. For a furnace of 1000 net tons this is 238 lbs. of lime per min., for 1 hr., in the case of iron made in a 6-hr. casting interval. It would necessitate an increase of 120 deg. F. in blast temperature during the hour. If added over 6 hrs., the rate would be 40 lbs. per min. and the increase in temperature 20 deg. F.

In practice the rate of addition will be determined by the chilling effect of the lime on the hearth. If the lime were injected immediately after cast, the higher lime slag would tend to stratify above the metal bath and might prove much more effective as a desulphurizer than the more acid slag formed when progressively diluted.

—Carl G. Hogberg, *Metals Tech.*, Vol. 10, Jan. 1943. Tech. Pub. No. 1523.

Foundry Practice

2

Melting and Pouring of Gray Iron, Malleable, Steel, Brass and Bronze, Aluminum and Magnesium Castings • Molding, Core-Making, Gating and Risering, etc. • Foundry Furnaces, Refractories, Ovens, Molds, Sands, Binders, Auxiliary Equipment and Materials

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Porosity in Navy Bronzes

Condensed from "American Foundryman"

The porosity encountered in Navy "G" and similar alloys is closely related. The lead in some of these alloys promotes pressure tightness and machinability. The same porosity often hidden in other castings by an unmachined surface is found in a cylinder liner. The one used as an example is 16 in. inside, 18 in. outside dia. and 24 in. long. It is to be finished and withstand 250 lbs. per sq. in. air pressure. The finished castings must be free of all imperfections and subject to test pieces cut from any section to check density and physical properties. The metal is composition "G" of the following specifications: Cu, 86 to 89; Sn, 7.50 to 11; Pb, 0 to 0.30; Zn, 1.50 to 4.50; Fe (max.), 0.10; Ni (max.), 1.00; P (max.) 0.05 per cent. Tensile strength, 40,000 lbs. per sq. in.; elongation in 2 in., 20 per cent.

Leaks Due to Porosity

Among causes of porosity due to imperfect foundry practice which will cause leaks in the castings are:

1. Low permeability of the molding sand, probably around 12 where 40 would be better. The holes are black, green, brown, red orange and yellow. They are water vapor holes from metal boiling in low permeable sand. One kind is seen by the naked eye, the other with a 10 power magnifying glass. Slag deposits are found.

2. Too wet molding sand, strong facings or wet blacking. A 10 power glass shows a crystal sugar appearance, the fracture being gray to golden yellow.

3. Ladles not dry. Fine orange to yellow holes are associated with gray to yellow crystalline structure on the fracture. This defect has a spongy appearance and is due to water vapor formed by pouring metal into a green ladle. Ladles should be lined with a mixture of silica sand and fire clay. If a crucible is used it should be preheated to a bright red.

4. Cope removed too soon. A fine crack with a dark crystal fracture shows that shaking out while too hot has caused uneven expansion and cracking.

5. Too rapid cooling. Fine, dark, checkered lines, showing after machining, indicate the casting has been placed in a sandblast while too hot, or the outside surface cooled by air or water spray. The casting should cool naturally in the mold.

6. Pouring metal too hot. An orange, yellow, or golden cleavage shows that pouring metal at least 200 deg. F. above the proper temperature has destroyed the advantage of directional solidification.

7. Overheating and soaking. This is characterized by a porous, evenly-distributed sponginess. The sprue may have shrunk but a small copper-tin button usually is forced out on top of the shrink. Metal should not be heated more than 100 deg. F. above the needed casting temperature and should not soak in the furnace.

8. Poor furnace combustion. This is indicated by clean brown, red, orange and yellow holes. The sprue and risers usually bulge on top. In oil, gas-fired and coke furnaces a slight amount of unburned oxygen in the combustion discharge is desirable.

9. Low hot strength. Porous grain structure shows that segregated alloy has drained from the casting because of its lower melting temperature. This may be overcome by use of more molding sand in the core mixture, addition of clay, of silica flour or of ferric oxide.

10. Improper gating and incorrect risers. A coarse crystalline structure of brown, red, orange and yellow on fracture shows internal shrinkage. For this casting a ring riser with four ⅜-in. pencil gates, used with a pouring temperature of approximately 2075 deg. F., should be used.

Causes of porosity which do not affect pressure tightness are:

Porosity and Pressure Tightness

1. Too low strength in the molding sand, probably 5 lbs. per sq. in. instead of 8. The holes, golden red to yellow, are caused by loose sand grains worked into the castings from the sprue and gate. Residue, sintered in the hole, may be seen with a 10 power glass.

2. Gas generated by a core buckle. This is usually associated with embedded core sand. The holes, in a straight line, are orange to golden yellow. Buckling is caused by pasting together overbaked and underbaked halves.

3. Gas from oxidized metal. The holes are dark red, black, green, orange and yellow in different castings. Oxidized metal should be reduced with phosphorus before pouring over cores.

4. Swab used too freely. The holes are clean, golden red to yellow and in a straight line. Slag formed by metal boiling in the sprue or runner forms similar holes. They can be traced by a fracture to the inclusion. Metal dissolving the lining of improperly glazed ladles shows similar results.

5. Dirty ladles. Small clear yellow holes in a straight line look like "flying geese." They are caused by a piece of oxidized metal entrapped in slag. Ladles should be clean and phosphorus put in the bottom with time allowed for reaction.

6. Steam holes or gas holes. Here golden

yellow holes show that water vapor or gas has been driven back into the castings by metal embedded in the sand of a soft spot just opposite.

7. Improperly drained charcoal. Small clean holes, orange to yellow, and possibly a granulated structure show that the water from the charcoal has combined with the metal.

8. Fins and cracks. A fin in the casting or a crack in the mold drives gas into the casting. Even sized clean holes are golden yellow.

9. Paste in core seams. Steam holes, large, clean and golden yellow, are caused by paste or mud in the core seams. They should be fitted with a fine molding sand and blackened over.

10. Dross inclusions. Oxide films resulting from excessive strings of oxidized metal appear red and green on fracture. Usually 0.01 per cent P added as 1½ oz. of 15 per cent phosphor-copper shot will correct this trouble.

In checking test bars that have failed, losses can be classified as follows: Water vapor, 75 per cent; gassed metal, 10 per cent; hot pouring, 5 per cent; cold pouring, 3 per cent; oxidized films within the bars, 2 per cent; other causes, 5 per cent.

The most outstanding results have been obtained by foundries using skin dried molds or cores and the fin gate bars recommended by the Navy and A.S.T.M. One company widened the riser at the top from 1 to 4 in. and tapered it to 5/16 in. where it joined the casting. This increased the elongation to better than 55 per cent, while maintaining high tensile strengths. The cores must be kept warm and dry. Water vapor must be guarded against.

—W. B. George, *American Foundrymen*, Vol. 5, Mar. 1943, pp. 7-12.

Mass Production of Cylinder Heads

Condensed from "Automotive and Aviation Industries"

The foundry management of Buick Motor Div., General Motors Corp., has developed an aluminum foundry operation which embodies novelties in technique and equipment that improve quality, reduce rejects and raise productivity.

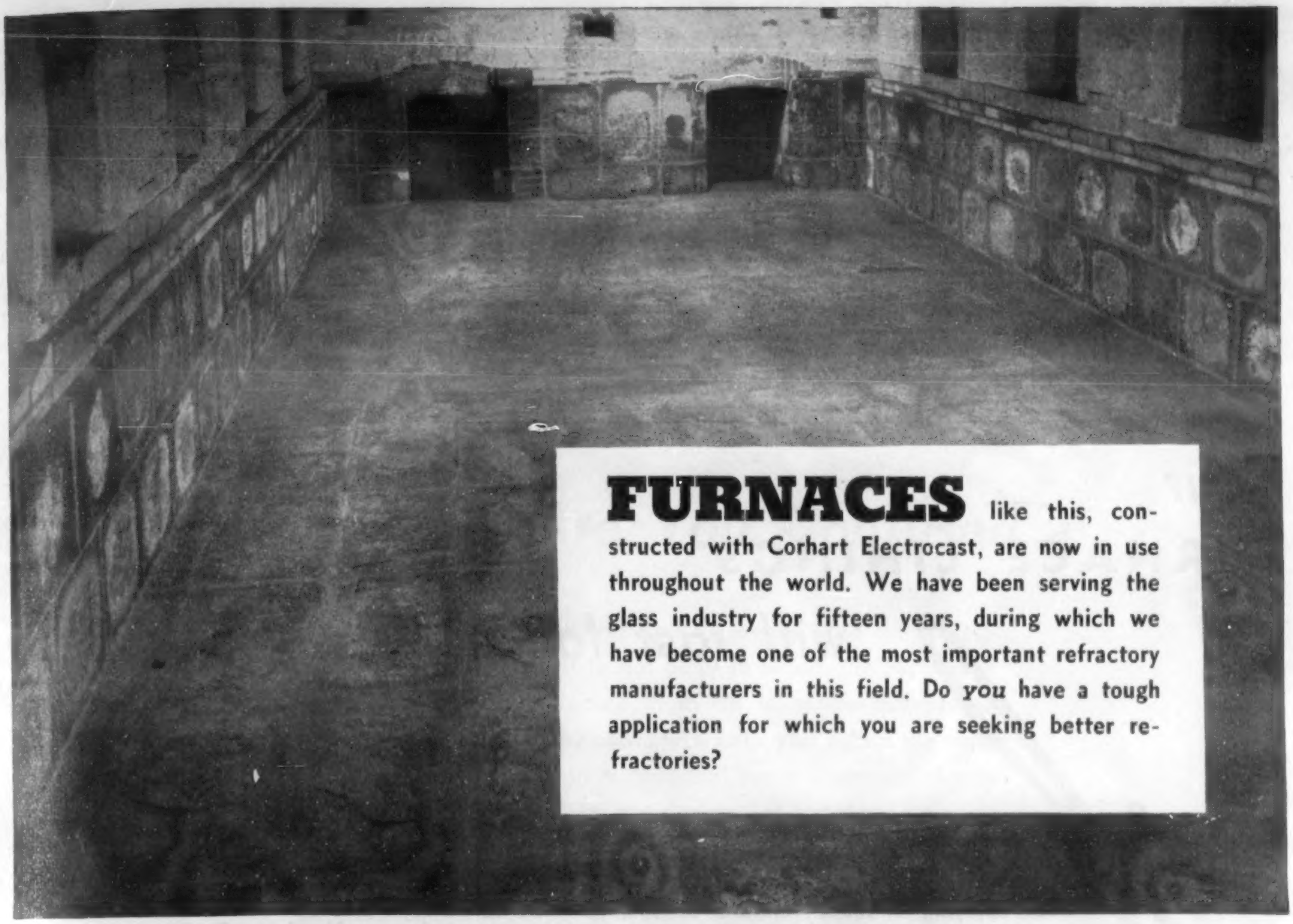
The most important basic principle is that the plant has been laid out for the production of but one type of aircraft engine cylinder head. Precision-built, massive pattern equipment, resulting in perfectly fitting and completely interchangeable cores, accounts for the beautifully fitted mold assemblies, perfection of casting detail and exceptionally low scrap loss.

Four factors responsible for exceptional control of quality are: 1. Control of facing sand; 2. technique of spraying cores; 3. technique of smoking or sooting of cores, and 4. control of melting and pouring temperature.

Foundry Features

The foundry has four self-contained units in parallel rows. Each has two separate molding lines containing molding machines, coreblowers, two core-baking ovens and one drying oven. Each has its own pouring station served by a battery of twelve 1000-lb. melting furnaces and its own shakeout. Stationary tables are used for pouring.

In the cleaning room the castings are chipped on the benches, the fins ground



The entire flux walls and bottom of this 16′ x 56′ glass furnace are constructed of Corhart Electrocast blocks.

Now Still Another Corhart* Uninsulated Bottom!

HERE'S another item to add to your "mental file" on Corhart* Electrocast bottoms.

In March, 1942, a well-known glass manufacturer installed his first uninsulated Corhart Electrocast melting-end bottom. On the strength of its performance, this customer has now installed another uninsulated Corhart bottom in another of his tanks. Both are of 12″ Corhart Standard Electrocast.

But these two tanks are by no means the only ones in which uninsulated Corhart bottoms are now being used.

In addition to numerous insulated bottoms, there are now at least THIRTY - EIGHT uninsulated Corhart bottom installations in glass tanks in North and South America. . . .

We knew you'd like to have these facts.

Corhart Refractories Company, Incorporated, Sixteenth & Lee Streets, Louisville, Kentucky.

*Not a product, but a registered trade-mark.

QUALITY ECONOMY ENDURANCE

CORHART ELECTROCAST REFRACTORIES

on special machines, then shot blasted in Pangborn machines. Buffing operations and another sand blasting are followed by the water test. They are then heat treated in Lindberg square, pit-type furnaces. Fixtures hold 120 heads at a time. Next the heads are shot-blasted again, given final inspection and conveyed to an automatic carton glueing machine. Test bars corresponding to each heat are certified by metallurgical laboratory tests before shipment.

At the front end a sand handling and reclaiming unit serves a bank of two molding units. Along the sidewalls are re-melting stations. Virgin metal is suitably alloyed and cast into pigs at the foundry. All scrap findings, gates and risers are salvaged. There are complete facilities for chemical and metallurgical laboratory work.

Molding Process

The heads are cast in dry sand molds (without the use of flasks) consisting of a drag and cope section assembled with combustion chamber core and two rocker box cores, produced by core blowing. The cope and drag are made up in Osborn semi-automatic rollover swingout type molding machines. After baking and cooling the cores are checked for dimensional accuracy. They are then blown and sprayed with a fluoride solution.

Before they are joined the two halves of the mold are sooted with a swinging acetylene burner flame. A special fixture built into the roller conveyor handles the assembly operation.

After pouring, the molds are cooled on gravity rolls and move to the knock-out stations. They are crane-lifted, reversed and placed pouring end down on 3 x 5 Simplicity vibrating knockouts. The casting is removed by hand and rough cleaned on a wood bench, where much scrap aluminum is reclaimed. Rods are removed on the knockout and the sand pushed over one end into an open chute. The knock-out time cycle corresponds to that for closing and pouring.

Outstanding Features

The knockout sand passes into cylindrical trunnion mounted breakers in the basement. It is then carried to a finishing breaker screen and conveyed to storage. No sand is wasted and the requirement for new sand has been reduced to about two carloads a day. Dust hoods and collectors of the wet type keep the basement dust free. Some of the recovered sand is given further treatment for re-use as facing sand. For this, Link-Belt oil-fired rotary kilns and Link-Belt rotary louvered shells for air-cooling are located in a separate building.

The generous number of conveyors and elevators play an important part in this mass production operation.

—*Automotive and Aviation Industries*, Vol. 88, Mar. 1, 1943, pp. 26-29, 47.

Aluminum Bronze Castings

Condensed from
"Foundry Trade Journal"

The production of aluminum bronze in the form of ingots, billets, sand and die castings has increased enormously since the outbreak of the war. Durville process, immersion casting process, centrifugal casting methods, production of sand castings, die castings, etc. are discussed.

So far as the manufacture of ingots and billets are concerned, little change has taken place during the past few years, and production by the Durville process remains more or less the standard method.

The main point in applying the Durville method to sand castings is the provision of a suitably designed runner and ingate system. The pouring basin, runner and ingate are cut off the mold by hand, a block core being inserted to obtain a partial reservoir of molten metal. This reservoir differs from that used in the production of ingots, inasmuch as it is not intended to hold all the metal required to run the casting.

It is only designed to hold enough metal to keep back surface dross and to allow the clean metal underneath to enter the mold. Pouring is commenced with the mold on an inclined plane, perhaps 60 deg. or more. The mold then is gradually lowered to a horizontal position while pouring is completed.

The immersion casting process was recently developed by Erichsen in Germany for light alloys (a new process for casting ingots: The Immersion Casting Process, by

Sven F. Erichsen, *Metallwirtschaft,* 1941, Vol. 20, pp. 270-275). Briefly, it consists of dipping a mold of special design into a bath of molten metal. By rapidly abstracting the heat from the metal within the mold, solidification in the bath is effected.

It is claimed that this method is particularly adapted to the production of slabs as used for rolling sheets, and, while so far the immersion process has only been applied to duralumin, there is no reason why it should not be applied to metals with a higher melting point, such as aluminum bronze. It is important to note that the rate of solidification of the slab depends upon the temperature of the melt, and in the case of aluminum, for example, the temperature of the molten metal bath must not be more than 70 deg. C. (140 deg. F.) over the melting point.

In centrifugal casting the best practice is to pour so that the metal strikes the rotating mold as nearly as possible in the center of the base, where rotation speed is lowest.

Turbulence of the molten metal during the casting operation must be kept at a minimum in order to prevent excessive drossing.

The paper is illustrated with sketches and photographs and contains data on the composition and mechanical properties of aluminum bronzes.

—Frank Hudson, *Foundry Trade J.,* Vol. 69, Jan. 28, 1943, pp. 69-76, 80.

Steel Castings for Canadian Arms

Condensed from "Canadian Metals & Metallurgical Industries"

Revolutionary developments in the production of castings have taken place in the foundry of the Ford Motor Co. of Canada, Ltd. Two Brackelsberg furnaces melt gray iron. Refractory costs are comparatively low and fuel costs somewhat lower than in the cupola.

Three-phase arc type, top charge Electromelt and Swindell furnaces produce the three steels used. The one electric furnace operating on a direct pour basis takes a 6½-ton charge. The others have a 3-ton rating but will melt 4-ton charges in about 1 hr. All the 3-ton furnaces are employed for melting but half of them also serve as holders. A charge from a furnace used strictly for melting is transferred to a holder in a 5-ton ladle. Final adjustments in composition are made in the holder. An empty holding furnace is temporarily converted to a melter.

The electric furnaces operate on the acid process, the charges consisting primarily of a good grade of scrap.

Casting Crankshafts

The steel used is approximately 1.45 C, 0.70 Mn, 1.00 Si, under 0.08 P, under 0.04 S, 0.42 Cr, and 1.25 per cent Cu. These crankshafts are poured in molds built up of 16 cores. Tests show a Brinell hardness of about 255, an ultimate strength of approximately 100,000 lbs. per sq. in. and an elastic limit of approximately 82,000 lbs. per sq. in. After cooling, grinding and normalizing the crankshafts are shot blasted and given a final touch up.

Steel used in casting hubs, brackets and certain other parts is melted in the electric furnaces. The charge is of pig iron, remelt and low carbon scrap. A steel known as No. 7 contains approximately 1.35 to 1.45 C, 1.00 to 1.10 Si, and 0.45 per cent Mn. Parts made of this steel are poured on a synthetic sand line, the sand being used over and over with additions to maintain proper characteristics.

The center pouring of the hubs requires the use of center pour cores of exceptional quality. The principal advantage of center pouring is that the metal in the sprue, being surrounded by hot metal, remains liquid longer, resulting in good shrinkage characteristics. Also better distribution in the mold results in a more easily balanced hub. These castings are normalized in a gas-fired furnace with five operating zones.

Cores are produced by blowing machines. For mass production of cores there is a revolving core-making table and a semi-circular arrangement whereby five men operate one core blower. Multiple blowing of small cores is employed. Roll-over machines produce copes and drags for vertical spinning operations.

No. 4 steel has an analysis of approximately 0.35 to 0.45 C, 0.70 to 0.90 Mn and 0.14 to 0.45 per cent Si. It is used on a synthetic sand line for the production of universal carrier treads and is the principal metal in revolutionary spinning processes.

The tread line contains a number of jolt

machines. Treads poured at the pouring station progress along the line to the automatic shakeout. After cleaning, rough spots are ground as the treads pass on a continuous belt and an automatic grinder snags the ends. In the first of the gas-fired furnaces the treads are brought to a temperature of 1650 deg. F. and then water-quenched. The second furnace operates at approximately 930 deg. F.

Centrifugal Casting

The only strictly centrifugal job is the production of airplane cylinder liners from No. 4 steel. The steel is melted in a small electric furnace. There is no center core. The wall of the cylinder is controlled to close tolerances by the weight of the metal poured. A spinning mold revolves at high speed until the steel has solidified sufficiently so that it may be removed without distortion.

Egg cup castings, part of the front wheel drive of certain vehicles, are centrifugally cast with a permanent mold. Weight as compared with those sand cast shows a reduction of nearly 50 per cent.

Spinning pots are mounted on a large circular table. In each is put a permanent mold containing a center core. When they are revolving at a proper speed No. 4 steel is poured. The rate of speed is not high but sufficient to assure production of a sound casting.

The most spectacular type of centrifugal casting is that of assemblies of several parts or clusters. Seventeen sections have been included in an assembly and overcoming certain mechanical considerations will allow more. The assemblies are placed in large spinning pots sunk in the floor and spun at relatively low speed, generating sufficient centrifugal force to ensure the metal being forced into each mold cavity.

Welded Tank Armor

To avoid the drilling necessary in riveted construction and speed up production there are three possible methods: 1. The use of cast plates and castings for gun turrets, etc.; 2. the use of a fabricated structure made up of welded plates and castings, if the latter are necessary; 3. the welding together of cast assemblies using specially treated castings to prevent the weld metal causing trouble at the joints.

Large steel armor castings require adequate heat treatment and hardening and tempering after machining to give the necessary bullet-resisting properties.

—G. L. White, *Canadian Metals & Met. Industries*, Vol. 6, Mar. 1943, pp. 16-19.

Magnetic Separation of Scrap

Condensed from "The Iron Age"

The main divisions of non-ferrous scrap are: (1) Junkyard scrap, consisting of old articles and pieces of non-ferrous metal contaminated with iron; (2) non-ferrous borings and turnings with small amounts of iron; and (3) intimately associated or entangled ferrous and non-ferrous scrap.

Separation is by magnetic pulley to which iron is attracted and held against a belt until it is carried underneath and past the influence of the magnetic zone. Non-magnetic material passes over the pulley.

Magnetic pulleys range in sizes from 12 in. diam .by 13½ in. face width, to 48 in. diam. by 63 in. face width. Pulley speed is about 50 r.p.m. for smaller sizes down to 20 r.p.m. for the larger. Capacity is from 400 cu. ft. to over 15,000 cu. ft. per hr. of scrap.

Turnings and borings require longer exposure to magnetic field than junkyard scrap because iron is somewhat entangled with non-ferrous material and so small that it is less susceptible to magnetic influence. The types used are drum, pulley and revolving separators.

The principle of operation is that the metal feeds into an inclined agitating tray and under a revolving disk. Primary induces magnetism in a series of secondary magnets set in the periphery of the disk. Magnets rotate out of the magnetic field and lose magnetism at a point where they overhang the table. They are able to pick iron off the table and discharge it to the side. In order to remove all the iron from entangled scrap, it is necessary to introduce agitation. For this job there is a machine which employs not only an agitating tray but also a magnet. Another unit suitable for separating entangled scrap is a magnetic drum. Materials separated by this type of machine are: Solder and metal filings; also concentration of sponge iron and similar materials.

—R. L. Manegold, *Iron Age*, Vol. 150, Nov. 5, 1942, pp. 56-58.

Metal-Working and Treating

Die Casting • Powder Metallurgy • Drop, Hammer and Upset Forging • Press-Forming, Drawing, Extruding and Stamping • Machining, Grinding and Polishing • Hardening, Tempering, Age-Hardening, Annealing and Malleableizing • Carburizing, Nitriding and Surface Hardening, Heating Furnaces, Refractories, Fuels and Auxiliaries • Welding, Flame-Cutting, Hardfacing, Brazing, Soldering and Riveting • Cleaning, Pickling, Degreasing and Sandblasting • Electroplating, Anodizing, Galvanizing, Metal-Spraying, Coloring, Buffing and Organic Finishing

CONTENTS

Martempering

Condensed from "The Iron Age"

Martempering is a term used to describe a heat-treating operation whereby martensite is produced with a minimum of residual hardening strains. It differs from austempering which definitely avoids the production of martensite.

Quenching practices have a major influence upon the potentiality of any steel and should be more closely associated with chemical composition when predicting the physical properties. Chemical composition restricts the range of potential physical properties. Methods of manufacture control the limits within this range.

Increases in hardenability for any given alloy content can be obtained by increases in carbon without danger of quench cracking or objectionable residual hardening stresses by use of a quench in salt at elevated temperatures or a timed water-elevated temperature salt quench. Such a procedure would greatly extend the field of usefulness of NE alloys.

The quenching method described below is an advance that must be made for maximum conservation of alloys. Using the new NE steels, desired structures are produced by preventing the A_r transformation or restricting the range of temperature over which it is permitted to occur. This control is obtained by proper quenching cycles.

Heating Process

The heating process is aimed at the production of homogeneous austenite. It must be conducted above the Ac 1-3 temperatures. It renders the steel capable of dissolving the excess constituents. The rate of formation of the austenite is a function of the chemical composition. The soaking time varies. Too long an exposure may increase the austenitic grain size causing changes in critical cooling velocity and alteration in desired physical properties. A higher temperature than necessary has the same effect.

Uniform austenite places the steel in proper condition to respond to controlled quenching and production of uniform maximum physical properties. Selection of a desired rate of quenching or cooling will control the final structure.

Quenching

Different rates of cooling are produced by quenching in liquid media — sodium hydroxide, 10 per cent brine, water, various kinds of oil, and for special steels, air, usually under pressure. Control is affected by the fact that the interior portions cool more slowly than the outside. A wide range of cooling rates can be obtained in each liquid depending upon the temperature and whether the part is immersed, agitated, quenched in spray or in a fixture under pressure.

Excessively high quenching rates cause hardening cracks, residual hardening strains, high enough to affect service life. Generally the slower the quenching medium, the deeper the steel will harden. Distortion increases progressively as the severity of quench is increased.

Excessive residual hardening strains may be present without cracks. They are the results or increase in volume and the difference in rate of contraction. The latter is due to differences in cooling rates and becomes greater as the speed of cooling is increased. Martensite is very hard and non-ductile and has no capacity for adjustment.

Martensite forms over a range of temperature, the point at which it starts, the Ms point, varying with different steels. For thorough hardening, the quenching rate must be such that the critical rate is exceeded in the center. There should be a minimum difference in temperature between the outside and center at the Ms point or cracking will occur.

If the piece could be quenched during the early stages of cooling in a fast medium so that the critical cooling rate would be exceeded in all sections (making martensite form) and then transferred to some bath at a temperature slightly above the Ms point, held there long enough for the center to catch up with the outside, further cooling could be permitted to occur in atmosphere to maintain minimum temperature differential. Martensite would form at a uniform rate throughout the matrix of austenite which, being soft, would adjust the stresses, with a minimum of resi-

dual strains resulting.

If the cooling rate in the liquid bath exceeded the critical cooling rate, the piece could be quenched there entirely, equalized in temperature and cooled in air. The soft bath temperature must be altered with the variation of the Ms point.

Data on quenching of 1, 2 and 3-in. rounds of NE 8744 show that at 400 deg. F. salt quenches faster than oil, and indicate that it would be faster on rounds over 3 in. in diam. There are also indications that the relief of stress may develop increased physical properties. The increase in hardness in the center obtained with a timed brine-salt quench over the straight oil quench in a 1⅜ in. round section of NE 8724 corresponds to an increase in tensile from 122,000 (25 Re) to 165,000 lbs. per sq. in. (35 Re) with a decrease in ductility from 23 to 18 per cent. No change in the distortion was produced.

Salt Bath Furnaces

Salt bath furnaces for quenching are low in cost, consisting of a pressed steel pot to obtain temperature uniformity and maxi-shell 8 in. larger in diam. and 4 in. deeper.

The salt is heated by G.E. Calrod units. They are controlled by an on and off switch, or automatically. A propeller stirrer may be mounted on top or a hot salt pump may be used to maintain circulation. This is to contain the salt, placed inside a steel mum cooling effect upon the work. When the operation is discontinued, a tapered plug is hung in the pot with the tip just above the elements, to prevent expansion troubles.

—B. F. Shepherd, *Iron Age,* Vol. 151, Jan. 28, 1943, pp. 50-52; Feb. 4, 1943, pp. 45-48.

Cold-Drawing Steel Tubes

Condensed from "Mitt. Kaiser-Wilhelm-Inst. Eisenforsch., Düsseldorf

The various methods for cold-drawing seamless tubes and the improvements made in the last years to obtain greater reduction (fewer passes) by improved tools are surveyed. Experiments are described and a theory is developed to determine the maximum permissible reduction in one pass for soft carbon steels.

The maximum reduction is a function of the product of the highest obtainable strengthening factor, *i.e.,* the quotient of final tensile strength and average deformation strength, the highest possible deformation efficiency, and the highest obtainable degree of stressing. The theoretical maximum for this reduction is about 65 per cent, but not more than 56 per cent was actually reached in the tests.

The highest strengthening factor obtainable in one pass, is about 1.4 and depends mainly on the material, and assumes a maximum in mild, not killed, open-hearth steels after a soft annealing treatment preceding the cold-drawing pass; thicker tubes have in general a somewhat higher value than thinner tubes.

The highest possible deformation efficiency lies at about 75 per cent, and is, in general, not much dependent on the kind of material. A great influence is exerted by the drawing conditions; these were,

however, not investigated very closely. For the maximum obtainable degree of stressing, the reverse conditions prevail with respect to the metallurgical production, the original dimensions and the kind of deformation, as they are for the strengthening factor and the deformation efficiency.

It reaches a maximum of 97.4 per cent in thin-walled tubes with predominant diameter reduction, and is about 90 per cent for killed steels and 80 per cent for non-killed steels. A previous treatment does not have much influence. The improvement in strengthening factor and deformation efficiency in non-killed steels is lost again by the embrittlement produced in drawing and the consequent lowering of the degree of stressing.

The investigations show that reductions of 50 per cent in one pass can be obtained under certain conditions in thin-walled tubes if soft and killed steels are employed. Tubes drawn from such steels possess, even without subsequent treatment, a very good deformability, and are resistant to aging. Tubes of non-killed open-hearth or Bessemer steels are liable to embrittlement during deformation so that the good deformability begins to disappear already during or after the cold-drawing. In any case, such tubes must be treated after cold-drawing.

—E. Siebel, H. Buchholtz & H. Frank, *Mitt. Kaiser-Wilhelm-Inst. Eisenforsch., Düsseldorf*, Vol. 24, No. 8, 1942, pp. 105-122.

Electro-Tinning Plus Induction "Flowing"

Condensed from "Metal Finishing"

Today's tin shortage has accelerated the development of suitable processing lines for the electrolytic deposition of tin on steel. The several types of tinning lines thus far developed have two basic differences. One difference depends on the method of starting a new coil of steel through the line. The other difference depends on the type of tank, whether vertical or horizontal. The two most dissimilar types of lines are discussed.

Production Line for Plating

In the constant speed, vertical tank type of line, the coil of steel to be tinned is placed on one of two uncoilers at the entry end of the line. The strip is 0.005 to 0.015 in. thick, up to 36 in. wide, and 3 miles long. The coil is about 5½ ft. in diameter and weighs 30,000 lbs. It is threaded through a pinch roll, an entry looper, the plating and rinse tanks, the master pull unit, the delivery looper, and the winding reel.

A line of this type usually has a maximum running speed of 500 to 600 ft. per min. because it is not advisable to have several strands of strip running faster than this through loopers whose top rolls are at times 30 to 35 ft. above the bottom rolls. The plating current is manually adjusted depending on the thickness of coating desired and the line speed.

In this type of line the plating tank anodes are suspended vertically cross-ways of the tank and the strip is threaded around rollers above and below successive anodes so that it passes in a vertical position between each successive anode. The upper rollers form the negative contact to the strip. When it is necessary to change

coils, as much strip as possible is accumulated in the entry looper. The line then operates on the strip accumulated in the entry looper while the new strip is welded onto the end of the finished coil. The change is thus made without changing the line speed.

Reels are changed in a similar manner at the delivery end. The principal advantages of this type of line are simplicity of control, relatively low power requirements due to low speed, and low installation cost due to the small speed range required of most of the motors.

The Horizontal Tank Line

The second basic type of line is the variable-speed, horizontal tank line. This line consists essentially of three units in tandem. These are: First, the plating unit, with uncoilers, drag roll, etc., and the plating unit; second, the reflow, or fusion unit; third, the shearing unit, with a pull unit, loop, flying shear, classifier, and pilers. This line has been designed for operation at 650 ft. per min. with provisions for speeds as high as 1300 ft. per min.

In this type of line the two sides of the strip are tinned in separate tanks, thus allowing variations in thickness and even in kind of metal deposited, if necessary. From the plating tank the strip passes into the fusion unit where a high frequency induced current melts the tin and produces a mirrorlike finish. It is then quenched in water, oiled, and the excess oil removed in a branding machine. Sheets that are too thick or too thin, or which have pinholes, are automatically rejected in the shearing unit.

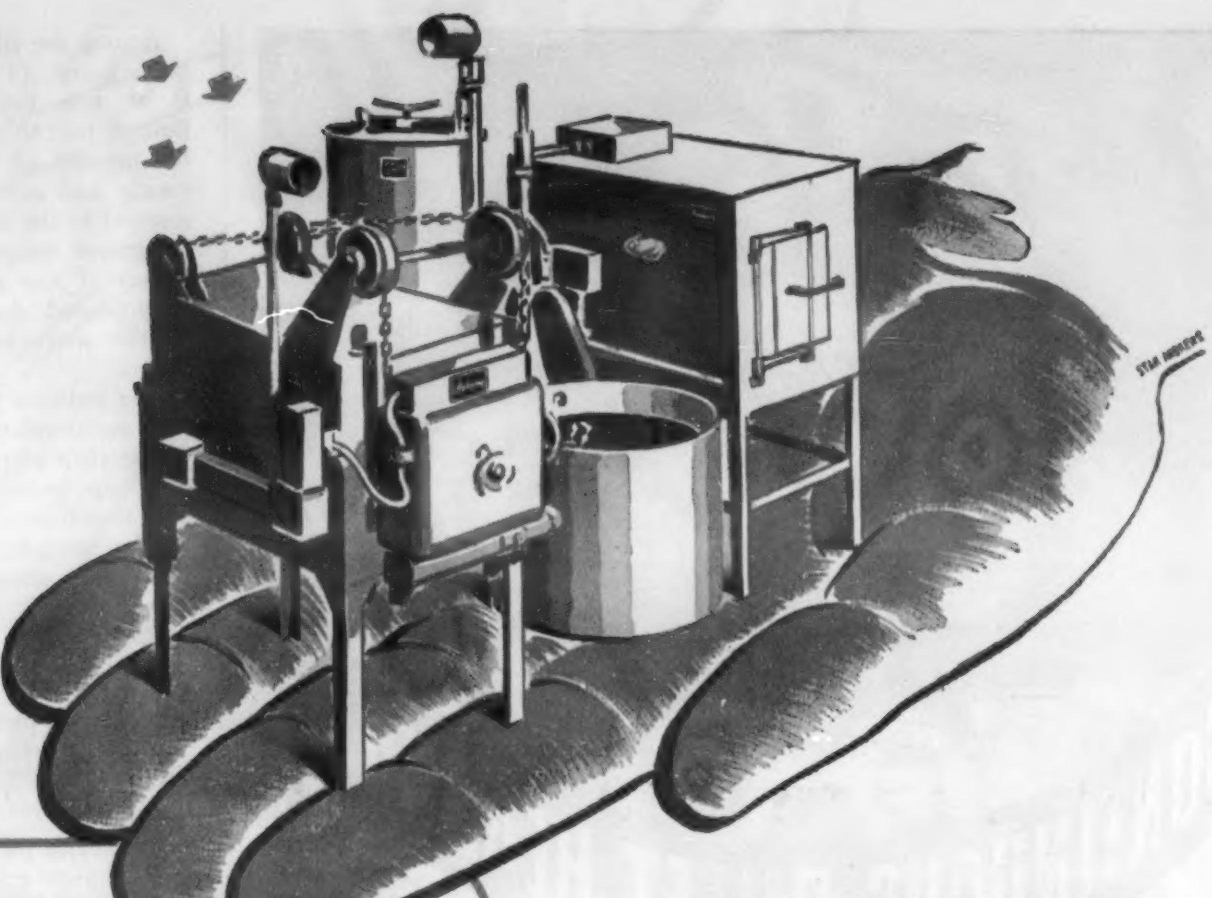
Automatic devices keep the strip under proper tension at all points in the line. An automatic electronic regulator adjusts the speed of the entire line for a given coating weight. This type of line requires about 3600 horsepower.

The fusion, or flowing, procedure is necessary not only to improve the appearance of the plate, but to increase corrosion resistance through reduction in the porosity of the plate.

Among the heating methods proposed for this step are: A hot oil bath; a radiant tube or some other type of furnace; electrical resistance heating; high-frequency induction heating; a combination of the above. The hot oil bath, or furnace methods require low strip speeds and separate operation. Induction heating is claimed to be the best method as it can be incorporated in the line and operated at the highest line speeds.

Induction Heating of the Coating

High frequency heating at 200,000 cycles per second (described in the second of the two articles referred to below), to melt tin electrolytically deposited on steel sheet, speeds production and facilitates mechanical handling. The electrolytic coating is only 30 millionths of an inch thick (about one-third the thickness of hot-dipped tin plate), and the fusion treatment is necessary to reduce porosity and increase corrosion resistance. In addition, the smooth coating so produced is necessary for proper operation of the suction cup feed on can-making machines.



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Among the advantages of high frequency heating are: (1) High speeds up to 1000 ft. per min. (oil baths or gas furnaces are limited to 150 or 200 ft. per min); (2) the amount of heat generated can be instantly and automatically adjusted to correspond to the line speed, thus maintaining the proper temperature and preventing oxidation of the strip; (3) no waste strip is produced due to scoring or marking of the sheet by electrical or mechanical action.

The inductor heater consists of a heater coil, rectangular in form, wound as close to the strip as possible and through which the strip passes. It acts as the primary of a transformer, while the strip itself acts as the secondary. The current induced in the strip generates heat within the strip. The power is supplied by vacuum tube oscillators.

—J. R. Erbe, *Metal Finishing*, Vol. 40, Dec. 1942, pp. 645-648; G. E. Stoltz, *Ibid.*, pp. 648-649.

Sputtered Metal Films

Condensed from "Light Metals"

The major purpose of cathode sputtering and vacuum evaporation processes is the production of metal films on the surface of articles. These films, which can be applied to any material, either conducting or nonconducting, exhibit the combined properties of thinness, uniformity, purity and adherence.

The processes are somewhat involved, yet when the equipment required is planned with care and operated under properly controlled conditions, no undue difficulties arise and they have been operated for many years to produce thin metallic films for specific purposes, such as electrical conductivity, capacitance, etc., or for optical reflectors or transmission.

Cathode sputtering is effected in a rarified atmosphere between the two electrodes. One of these, the cathode, is the material to be deposited as a sputtered film. The cathode is maintained at a high negative potential with respect to the anode, and an intensive electrostatic field is created between them. In this field the relatively heavy positive ions of the residual gas, directed toward the cathode, impact upon it and dislodge or tear out particles of the material.

These particles are probably of molecular dimensions; carry a negative charge, and therefore travel toward the anode along the electrostatic field. An object placed in the electrostatic field mechanically intercepts or filters from the stream the negatively charged particles and becomes coated with the cathode material.

By arranging for uniformity of fields, a uniform cathode layer is built up, the thickness of this layer being determined by the total time period of the operation. Sputtering, by virtue of the fact that films are built up by molecular deposition, is convenient for providing exceptionally thin coatings.

Evaporation, on the other hand, is relatively rapid and the thickness of the film is controlled by the quantity of material evaporated. This evaporation is accomplished in a rarified atmosphere, but the process is not as involved as cathode sputtering. The vacuum is required to lower

the boiling point of the metal and prevent oxidation. Electrical heating is almost universally employed and for some materials a refractory crucible wound with an electrical element suffices. For others, the material is actually evaporated from a coil or filament rapidly heated to temperature by the passage of the current.

In consequence of the numerous commercial application employing the unique properties of these films, a review of the salient features from established practices and literature are discussed.

—*Light Metals*, Vol. 6, Feb. 1943, pp. 56-79.

Heat Treating of Aluminum and Magnesium in Gas Furnaces

Condensed from a paper before the American Gas Association

The accelerating growth of aluminum production, most of which will require heat treatment, opens a present and future market for industrial gas equipment. Gas companies and equipment manufacturers should cooperate to put the right kind and size of furnaces on the market.

American Gas Association's Project No. 1 subcommittee has found that present specifications for aluminum alloy heat treatment do not interfere with the successful application of gas heat. Information at hand indicates a much more widespread use of direct furnaces for heat treating cast alloys than had been suspected.

A number of natural gas applications are used in the driers employed after chemical purification of aluminum ores. There is opportunity for gas application for the remelt furnaces, ladle heating, and auxiliary plant uses. The most important heat-treating work, from the point of view of the gas industry, is the final heat treatment. For this there are now many gas installations. In general they are indirect gas furnaces. However, alloy No. 195 is typical of the group which can be successfully handled by direct-fired furnaces and even the difficult alloy No. 356 has been so handled.

As an example, a review of the situation in Detroit shows that, there, approximately 77 per cent of the aluminum is heat treated in gas-fired furnaces. Up to the present time there is no gas furnace suitable for handling long extruded shapes.

It is also probable that light weight magnesium alloys requiring heat treating will be increasingly important. The Superior Bearing Bronze Co., Brooklyn, N. Y., is successfully using direct gas-fired recirculating furnaces for heat treating magnesium castings. Tests in the oven show practically no temperature variation. The castings show no evidence of pitting, melting or burning. These furnaces reduce the total concentration of oxygen on account of the flue products produced. Thus the tendency to oxidize magnesium should be diminished. As clean castings which have been sand blasted prior to heat treatment introduce no magnesium dust into the furnace, the direct gas furnace has no greater fire hazard than other types.

—C. George Segeler, *American Gas Association*, Mar. 11 and 12, 1943.

Metal Finishing of Aircraft

Condensed from "Proceedings," Amer. Electroplaters' Society

Very little untreated aluminum alloy is used in a military plane today. Even though the corrosion resistance may be satisfactory without painting or anodizing, modern warfare demands camouflaging.

Prior to applying any type of finish to aluminum, oil films are removed with vapor degreasing or with an inhibited alkaline wash. Phosphates, silicates and soaps serve as inhibitors. A formula used by the Army Air Force overhaul depots contains trisodium phosphate, 6 lbs.; disodium phosphate, 6 lbs.; sodium metasilicate, 6 lbs.; sodium carbonate, anhydrous, 6 lbs.; soft soap, 4 lbs.; water, 100 gallons; temperature, 210 to 212 deg. F.

Aluminum may be anodized following cleaning to produce a relatively thick and corrosion resistant oxide film. In the chromic acid process the work is made the anode in a steel tank containing a 5 to 10 per cent chromic acid solution. The bath is operated at 95 ± 4 deg. F. and is heated with steam coils and agitated with filtered air. A low voltage is applied initially. It is raised as rapidly as possible to 40 volts. Anodizing is continued for 30 min. after which the work is rinsed in cold water, hot water, and dried.

In a typical sulphuric acid anodizing process the electrolyte is a 15-18 per cent sulphuric acid solution operated at 70 ± 2 deg. F. A lead lined tank is used. Air agitation and cooling are necessary. Full voltage of 10 to 24 volts, depending on the alloy, is applied at once. After 20 min. anodizing, the parts are rinsed and transferred to a boiling 5 per cent sodium or potassium dichromate solution. After 20 min. treatment the parts are rinsed and dried.

The Process of Chromadizing

Chromadizing is a process used to improve paint adhesion and consists of immersion in a 5 per cent solution of chromic acid at 120 to 140 deg. F. for 1 to 2 min.

A treatment which serves the same purpose as chromadizing consists in applying a solution containing, on a volume basis, butyl alcohol, 40 per cent; isopropyl alcohol, 30 per cent; 85 per cent phosphoric acid, 10 per cent; water, 20 per cent. This is applied with a rag or by dipping or spraying. After 1 or 2 min. the surface is scrubbed lightly with a brush, rinsed thoroughly, dried, and primed immediately.

Chemically formed oxide films do not have the corrosion or abrasion resistance of an anodic film, but form excellent bases for paint. In a typical process of this type (Alrock Process), the aluminum alloy is treated with a dichromate-sodium carbonate mixture, after which the oxide film is sealed by boiling in a dichromate solution.

The sodium silicate process is used primarily to seal pervious castings which must hold pressure — 40 deg. Bé water glass is diluted with 4 volumes of water and the clean casting is immersed in the solution at 150 deg. F. After 30 min.

it is removed, drained, and baked 30 min. at 300 deg. F. When cool the parts are immersed 1 min. in cold 5 per cent sulphuric acid, rinsed, and allowed to dry at room temperature.

Two Treatments for Magnesium Surfaces

Treatments of magnesium surfaces are largely for the purpose of improving paint adhesion and have in themselves little protective value. Two common treatments are the chrome pickle and the dichromate boil.

In the chrome pickle process the part is immersed for 30 sec. to 2 min. in a solution of 1.5 lbs. per gal. of sodium dichromate and 1.5 pints per gal. of nitric acid, at a temperature of 50 deg. C. (122 deg. F.). The work is then rinsed in cold water. This process removes about 0.0006 in. per surface.

Where tolerances are small, the dichromate boil is suitable. Following cleaning, the work is given a pre-treatment dip in a 15 to 20 per cent (by weight) hydrofluoric acid solution. The work is then immersed for at least 45 min. in a boiling 10 per cent sodium dichromate solution (Dow No. 7 Treatment). The pH should be maintained between 4.2 and 5.5 by adding chromic acid. This treatment is suitable for all magnesium alloys except Dowmetal M and AM3S.

Steel parts in contact with aluminum are cadmium plated to prevent accelerated corrosion of the aluminum by direct contact with steel. A black oxide finish has been used on steel propellers for its camouflage effect. Phosphate coatings are used on steel for paint adhesion.

Plating with Chromium and Copper

Chromium plating is used on piston tubes for shock absorbers and for the repair of certain engine parts. The use of chromium as a repair medium is limited to parts not too highly stressed, due to the reduction in fatigue strength caused by chromium plating. The Van der Horst chromium process is being tried experimentally on engine cylinders to replace nitriding.

The use of copper plating is limited to anti-seize surfaces, to areas to be copper brazed, and areas to be stopped off from carburizing. Tin plate is used as an anti-seize surface and as a stop-off for nitriding.

Silver bearings will stand extremely hard service. They are made by plating or brazing a silver shell on a steel back. They are then plated successively with lead and indium and heated to diffuse the indium into the lead. The lead forms a self-lubricating film and the indium reduces the corrosion of the lead by oil acids.

In painting aircraft parts, color coats may be applied directly to anodized aluminum or phosphatized steel, or to other surfaces which have already had an effective corrosion inhibiting and adhesion-improving treatment. Zinc chromate primer should be used on aluminum, and a suitable primer, usually iron oxide plus about 30 per cent of a chromate pigment, should be used on steel.

Magnesium must be treated with one of the chromate treatments described and

should have a zinc chromate primer followed by water resistant top coats.

The quick-drying synthetic varnishes and enamels are superior to lacquers for corrosion resistance, but all types of paint are effective on properly prepared and primed surfaces. Slow-drying varnishes and enamels made from natural resins and oils are not applicable to present production schedules.

—E. R. Irwin & J. Teres, *Proc. Am. Electroplaters' Soc.*, 1942, pp. 134-139.

Pickling of Cartridge Brass

Condensed from "Sheet Metal Industries"

Pickling is one of the least standard operations and therefore one of the most likely to give trouble in the manufacture of cartridge cases. Care must be taken to see that the residue of the lubricant employed in drawing is satisfactorily removed before annealing, either by rinsing thoroughly in water or by rubbing off.

After the parts have been annealed, there is on the brass a deposit consisting largely of black CuO with some traces of Cu_2O and carbon. The usual scale contains more zinc oxides than copper oxides; however, the exact scale composition depends mainly on the annealing temperature and the furnace atmosphere. The lower oxide of copper (most of which is present on the inside of the case) may occur where some lubricant residues have been reduced to carbon. Small globular pink areas which sometimes are found appear to result from splashing of alkaline rinse water and to lack of a subsequent wiping.

The Furnace Baskets

Furnace baskets, which may or may not pass through the pickle, are made from Monel, Inconel, Nichrome, 35 Ni-15 per cent Cr, 19 Cr-9 per cent Ni, or various other stainless steels. Nichrome is most economical if the baskets are used for both annealing and pickling. The life depends on plant conditions.

The main disadvantages of the Nichrome are a tendency towards cracking and fairly rapid embrittlement. If stainless steels are used, they must be resistant to carbide precipitation. Some recommend adding $CuSO_4$ to the acid to passivate the stainless steel but this is considered undesirable from a pickling angle (not so in the U.S. —J.Z.B.)

Monel pickling baskets should be in galvanic contact with the brass and should be completely immersed in the pickling solution; if this is not possible, Hastelloy C is a better choice. The preferable practice is to use stainless steel baskets in the furnace and separate Monel baskets in the pickle, but perfectly good results are obtained when Nichrome is used for both although more frequent repairs will be needed.

It is customary to cool the cases as they come from the annealing furnace with jets of cold water. The advantages are: 1. Considerable scale is cracked off; 2. the cooler cases give less acid vapor on entering the pickle; 3. a better pickled surface is obtained. The cooling water should not be re-used as a rinse as it will give excessive amounts of copper in the latter.

Non-automatic immersion pickling is the oldest method of pickling. It is satisfactory with suitable control, but many drawing troubles may be caused by improper pickling.

Automatic immersion pickling with dormant solutions uses three tanks: Acid tank, heated by steam coils; acid wash tank, not heated; and the rinse tank, heated by direct steam injection. The tanks are usually lead-lined as rubber lining limits the temperatures, limits the arrangements of the steam coils, and makes it necessary always to add water before H_2SO_4.

Automatic Immersion Pickling

Automatic immersion pickling with agitated solutions is fairly modern and is suitable for the smaller classes of cartridge cases. Three drums, rotating in a horizontal direction, with baffles are used. The liquid remains in the bottom, while the cases are carried up the sides, then they fall back into the solution. The cases discharge from one drum to the next at a uniform rate. The three solutions are the same as for automatic immersion pickling with dormant solutions.

However, if the drums are directly connected to the annealing furnace, the cartridge cases are not pre-cooled and there is no necessity for heating the acid bath. Also the rinse may be fairly alkaline or a 0.2 per cent soap solution to neutralize the acid. This method involves severe mechanical agitation, but it apparently causes no harm except in the later operations where the walls of small cases may be too thin to stand it.

In the automatic spray pickle, a tunnel, jetted from all sides is used. There are three sections with intermediate draining periods. The solutions are the same as for automatic immersion pickling with dormant solutions. The continuous conveyor band to convey the cases may be Nichrome or rubber covered steel wire. In the earlier draws, the cases are packed direct on the conveyor; the taller tubes are packed first in Nichrome baskets. The authors favor immersion rather than spray pickling.

Sulphuric Acid Pickle the Best

The authors investigated a number of pickles, but found that H_2SO_4 with proper control was best. The optimum temperature range was 120 to 140 deg. F.; at higher temperatures there was a tendency to form dull red stains and to attack the rubber linings. The period of treatment was not critical. With a dormant soak, 1 to 5 percent was the best concentration. With agitation, no difference was noted with concentrations from 1 to 20 per cent; however, the higher acid concentrations would be undesirable since they would give a quicker contamination of the rinse. Therefore, 2.5 to 5 per cent is recommended.

A constant check should be made of the acid concentration by diluting a sample (to reduce the blue color) and titrating with normal Na_2CO_3 with BHC indicator No. 2 (methyl orange second choice as indicator).

Laboratory tests with a 10 per cent solution of sodium bisulphate (from the manufacture of nitro-glycerine) at 140 deg.

F. gave results very similar to those obtained with H_2SO_4. It is reported that in practice, a hot rinse must be used following the sodium bisulphate pickle rather than the normal cold one.

In laboratory tests, with a dormant soak, the presence of even 1 per cent $CuSO_4$ decreased the brightness of the brass surface and gave some tarnish. Higher percentages were permissable with an agitated soak. The generally accepted maximum in spray pickling is 2.5 per cent $CuSO_4$, although it may go as high as 3 per cent if other conditions are favorable. If the rinse water is hard, the permissible $CuSO_4$ is even lower. Frequent and regular checks must be made to the amount of copper in solution. A fairly rapid volumetric method is given involving mixing with potassium iodide and titrating the liberated iodide with a standard thiosulphate solution.

In dormant solutions, even 20 per cent $ZnSO_4$ has no effect on the pickle; in agitated solutions, smaller amounts have no effect but 20 per cent gives a more coppery, duller pickled surface. In practice, no difficulties are encountered due to zinc in solution.

The presence of iron in soluble form (ferrous sulphate, ferric ammonium sulphate, ferric sulphate) even up to 20 per cent has no effect. However, the presence of mild steel (either in contact or not with the brass) gives a coppery surface or forms copper patches on the brass. Therefore, iron must be excluded from the pickling vats. With "bright stainless steel, unannealed" (type not given), the results are definitely less coppery than with mild steel, but sufficient contact stain is produced to cause serious trouble in the subsequent draws.

Effect of Lead

Lead may be present in the sludge. Since metallic lead will give rise to copper deposition if it comes in contact with the brass, and since a sludge may cause local variations in acid concentration due to adsorption, the sludge should be removed regularly.

A brief resume of the field of water supplies and their treatment is given. The authors recommend that the water used should be closely examined by an expert with particular attention being directed to the possibility of staining being caused by the rinse water.

The rinse following the pickle should be cold (except for the sodium bisulphate pickles); 95 deg. F. is given as a maximum temperature. The final rinse may be hot or cold, but it is usually hot to give rapid drying. Cases at 170 deg. F. dry immediately at the delivery end of the machine. If rubber linings are used, the temperatures should not exceed 160 deg. F.; therefore, lead lining is preferable. Cases must be dry before they are immersed in the lubricant for subsequent drawing.

Rinsing time is an important factor. Cases left in the first rinse for any length of time are liable to pick up an uneven brown stain. The time in the final rinse should be long enough to give a hot case which will dry immediately.

The acidity of the first rinse should not be allowed to fall below 0.2 nor rise above 0.5 per cent free H_2SO_4. The acidity of the final rinse is generally 0.015 to 0.05 per cent H_2SO_4. While a dilute soap solution has been used for the final rinse, it has proven unsatisfactory in many instances.

Possible Defects Diagnosed

Diagnosis of possible defects are given in the table which follows:

Appearance of case	Possible cause	Control
Localized copper coloring	Presence of concentration cells in pickle	Reduce copper content of pickle
Dull brown patches	Presence of iron not in contact with metal	Examine interior of pickling plant
"Blood" spots (bright red spots)	Iron in contact with metal	Examine interior of pickling plant; possibility of iron particles picked up in drawing; examine blanks
Copper spots (not as bright as above; well defined edges; generally depression near to spots)	Alkalinity of drawing medium or rinse water after drawing	Reduction of alkalinity in drawing operations
Blue black tarnishing (may be metallic green or black; very irregular)	Alkaline water with $CuSO_4$	Reduction of copper in pickle; attention to rinse water composition
Copper flashes	Chlorinated solvent	Elimination of use or protection of plant; remove from vicinity of annealing furnace
Intense brown patches	Iron in contact with brass with excessive oxidation	Insulation of work or use of metal or alloy with less difference in potential to that of copper
Green brown streaks	Cases too closely in contact with one another	Wider spacing of cases; use of "dividers"
Green brown tarnish	Over-rinsing with too alkaline water	Re-pickle
Tadpole marks	Cases covering each other in pickle	Separation of cases

Effluent treatment is generally necessary because of local laws concerning pollution of streams. The pre-rinse, overflow from the first rinse, and final rinse are generally combined and neutralized with caustic soda (hard to handle, probably more expensive), sodium carbonate (cheap, usually most favored), or lime (may be cheaper). It may or may not be necessary to allow the precipitate to settle before passing into the river, etc.

The waste pickle is less voluminous but more concentrated. Dilution is possible but uneconomical. It is sometimes neutralized with lime or soda ash (usually the former), more frequently followed by precipitation and filtration. In more modern plants, the waste pickle is treated to recover the metals and acid (see below).

If the press pit effluent is mixed with the pickle effluent before treatment, there may be trouble due to the soaps and oils in the former. Acid recovery from the waste pickle is a wartime measure; apparently it is not economically sound. The waste pickle liquor is electrolyzed until the copper is under 0.01 per cent (anode is lead lining of tanks; rotating copper gauze cathode). So the sulphates are converted back to H_2SO_4.

Zinc recovery is much less economical, and the efficiency is very low. A continuous acid resisting cathode is used. After a flash coating of zinc, this zinc is then stripped in an alkaline $ZnSO_4$ bath.

The copper can be recovered more cheaply by allowing the waste pickle to flow over scrap iron; 96 per cent of the copper is recovered, but none of the zinc or acid.

—H. A. H. Crowther and P. D. Liddiard, *Sheet Metal Ind.*, Vol. 16, Nov. 1942, pp. 1711-1714; Dec. 1942, pp. 1903-1909; Vol. 17, Jan. 1943, pp. 97-108; Feb. 1943, pp. 291-296, 303-304; Mar. 1943, pp. 493-496.

Zinc Plating Instead of Cadmium

A Composite

The demand for cadmium, now used largely for electroplating in military applications, exceeds the supply. Zinc is used as a substitute, but is not suitable for all applications. Two recent articles in a British journal and an American publication provide some interesting sidelights on the cadmium-zinc situation and some good practical advice on the operation of cyanide zinc baths. Some of the problems in substituting zinc plating are discussed by Gustaf Soderberg *(Monthly Rev. Am. Electroplaters' Soc.*, Vol. 30, 1943, pp. 78-80):

Mallory Tips and Holders Speed Spot Welding

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	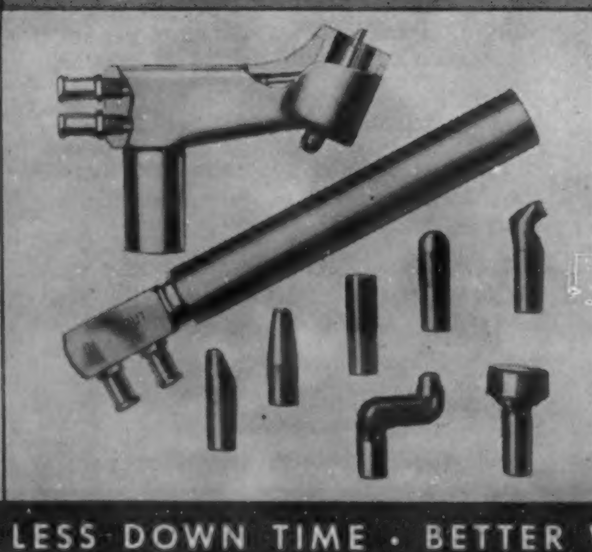	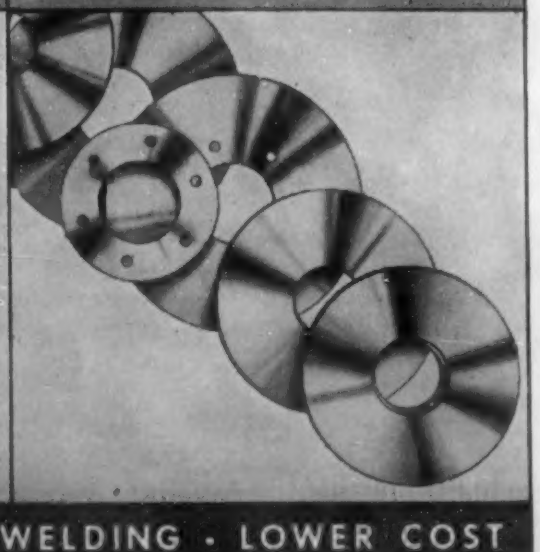

SPEEDIER PRODUCTION · LESS DOWN TIME · BETTER WELDING · LOWER COST

Zinc corrosion products restrict free movement of moving parts, rot cloth, and have a high contact resistance. Cadmium should be used in applications where these effects are harmful. Cyanide zinc plating has a greater embrittling effect than cadmium, and gray or malleable iron castings are difficult to cover with zinc.

A cadmium bath should not be changed to a zinc bath simply by inserting zinc anodes. A chromate film on zinc delays the formation of white corrosion products and increases the rust protective value, but care and experience are required to successfully apply chromate coatings.

Direct experience with alkaline zinc plating is reported at length by J. S. Jones & P. M. Walker. (*Jour. Electrodepositors' Tech. Soc.*, Vol. 17, 1941-1942, pp. 155-163), for in England the high price and restricted supply of cadmium have also forced its replacement by zinc in many applications. Bright zinc deposits were found to be as good as cadmium in many applications, and were superior in some respects.

For example, in one instance blackening of cadmium plate during storage was the cause of much trouble and loss, whereas bright zinc in the same application did not blacken. Another advantage is that bright zinc is less subject to fingermarking than is cadmium.

In making the change from cadmium to bright zinc, tanks formerly containing cadmium solutions were thoroughly cleaned by scrubbing, soaking with a hot dilute hydrochloric acid solution, rinsing, making anodic for 24 hrs. with a hot 3 per cent solution of sodium cyanide, followed by a final rinsing.

The same cleaning procedures used in preparing work for cadmium plating are satisfactory for bright zinc. It is important to rinse work in a 10 per cent sodium cyanide solution before placing it in the zinc solution.

A Bright Zinc Solution

A proprietary bright zinc solution which gave good results has the following composition:

Metallic zinc	6.0-7.5 oz. per gal.
Free cyanide	7.5-9.0 oz. per gal.
Total cyanide	16.5-20.0 oz. per gal.
Free sodium hydroxide	10.0-14.0 oz. per gal.
Sodium hyposulphite	0.5-0.75 oz. per gal.
Brightener	0.2 oz. per gal.
Current density	15-20 amp. per sq. ft.
Deposition rate	0.0008 in. per hr.

For lustrous deposits it is necessary to maintain the following ratios:

1. Total cyanide concentration: metallic zinc concentration to be maintained at 2.5-3.0;

2 Free cyanide concentration: zinc cyanide concentration to be maintained at 0.65-0.75;

3. Sodium hydroxide concentration: zinc cyanide concentration to be maintained at 1.0-1.3.

The anodes dissolve when the bath is standing idle and should therefore be removed. It is very important to avoid contamination by heavy metals, especially cad-

mium, copper, and lead. Anodes should be 99.99 per cent pure, and the sodium cyanide pre-dip should be kept clean and uncontaminated. Addition of about 1 lb. of zinc dust per 100 gal. of solution, followed by filtration, is an effective purification treatment.

After plating, the work is transferred as rapidly as possible to a cold water rinse, and then to a 0.5 per cent solution of nitric acid for 3 to 5 sec. The deposit is a mat, yellow-green color on emerging from the plating bath, but comes from the nitric acid bright dip with a brilliant lustrous appearance. Following the bright dip the work is rinsed in cold water, hot water, and dried.

Barrel Plating with Zinc

Difficulties were encountered in barrel plating with zinc. Certain mechanical changes and a change in the solution composition led to successful bright zinc barrel plating. Mechanical changes included installation of a cooling coil and air agitation, and the use of flat semi-circular anodes placed as close as possible to the barrel, in the place of ball anodes. The temperature is controlled between 15 and 20 deg. C. (59 and 68 deg. F.).

A satisfactory solution contains:

Metallic zinc	5 oz. per gal.
Free cyanide	5.5 oz. per gal.
Free sodium hydroxide	6 oz. per gal.
Sodium hyposulphite	1 oz. per gal.
Brightener	0.5 oz. per gal.

A barrel speed of 14 r.p.m. was used, but the authors believe that a reduction to 7 will improve the results. Plated parts must be rinsed and dried quickly to avoid staining.

Complete directions are given for analysis and control of the solutions.

Heat Treating the N.E. Steels

Condensed from "Steel"

The NE steels from 8615 through 8749 respond to normalizing treatments for machinability somewhat as do the regular SAE steels except that, in general, somewhat faster cycles can be used for equivalent carbon contents. The carburizing grades, especially, can be annealed faster with less tendency to form martensite as a result of too early withdrawal from the furnace at temperatures below 1000 deg. F.

It is suggested that drilling, shaping, and broaching might best be done with a straight air cool from the normalizing temperature when using NE 8620, if the smoothest finish is required. Where the NE 8600 and 8700 carburizing grades have been substituted for pre-war steels, there has been no sacrifice in finish. Machinability of the medium and higher carbon NE 8600 and 8700 steels used in the automotive field is good.

Carburizing

NE 8620, 8720, and 8817 carburize very similarly. The carbon concentration of these steels, carburized simultaneously at 1680 deg. F. in a high percentage choke-charcoal compound, was 1.15, 1.19, and 1.16 per cent, respectively, at a depth of 0.0025-0.005 in.; 0.86, 0.88, and 0.86 per cent, respectively, at 0.020-0.025 in.; and 0.40, 0.46, and 0.46 per cent, respectively, at 0.045-0.050 in.

A comparison was made between the carburizing characteristics of NE 8720 and SAE 4620 carburized adjacent to each other in coke-charcoal type compound at 1700 deg. F. and also in a pit-type gas carburizer at 1650 deg. F., using a liquid-type carburizing agent. The carbon content at the following depths of the pot-carburized specimens was, respectively: 0.000-0.0025 in., 1.19, 1.16 per cent; 0.0025-0.005 in., 1.17, 1.11 per cent; 0.005-0.010 in., 1.13, 1.10 per cent; 0.020-0.025 in., 0.84, 0.80 per cent; and 0.045-0.050 in., 0.38, 0.38 per cent.

For the gas-carburized specimens, carbon content was, respectively: 0.000-0.0025 in., 1.28, 1.08 per cent; 0.0025-0.005 in., 1.06, 1.03 per cent; 0.005-0.010 in., 1.04, 0.97 per cent; 0.020-0.025 in., 0.78, 0.69 per cent; and 0.045-0.050 in., 0.36, 0.030 per cent. Total case depth by Brinell microscope was 0.058 in. for both pot-carburized specimens and 0.060 in. for both gas-carburized ones. These results indicate that NE 8720 is more reactive to gaseous carburizing media.

The carburized cases of these steels (8620, 8720 and 8817) have some degree of malleability as the corners of the cases produced in actual gears can be peened with hammer blows without chipping. Fracture tests of case and core of both direct-

quenched and reheated parts so far appear to be somewhat coarser than those of the former steels with more nickel, chromium and molybdenum. There is more tendency to form crystalline breaks, especially in the core, as compared with fibrous breaks such as are common to SAE 4620.

Hardening

Results of end-quench tests of commercial heats of these steels conform with the early information published by the American Iron and Steel Institute.

A series of quenching cycles in which ½ in. thick disks of these steels were successively quenched from 1475-1550 deg. F. in increments of 25 deg. F. indicated that a reheating temperature of at least 1525 deg. F. should be used to harden the cores fully. Similar tests with NE 8744 and 8949 showed that no increase in hardness was obtained above 1475 deg. F. for the former nor above 1425 deg. F. for the latter.

Unless the furnace atmospheres are controlled, it is a task to keep decarburization down and to avoid the "soft skin" that often occurs with the straight-chromium, chromium-molybdenum, and chromium-vanadium steels. Where no grinding of the working surface is done, NE 8620, 8720, and 8817 resemble the SAE 4600 and 4800 series, which are well known for their truly file-resistant cases even under poor hardening conditions. This new series has similarly shown low distortion characteristics typical of the pre-war nickel steels.

Various laboratory dynamometer tests and breakdown tests in the field indicate that this series is adequate for many uses without fear of experiencing trouble from its adoption.

—Thomas A. Frischman, *Steel*, Vol. III, Dec. 14, 1942, pp. 99, 119-123.

Powder Metallurgy

Highlights of the March A.S.T.M. Symposium

The symposium on powder metallurgy, held by the A.S.T.M. at Buffalo in March, was a very well-attended presentation of the general state of powder fabrication today, with a few interesting new developments reported.

Charles Hardy, in discussing fundamentals in applying powder metallurgy, covered first raw material and its preparation. He stressed that most of the powders used on a large scale are the product of the reduction of metal salts by gases, by electrolysis or by atomization. Tungsten, for instance, is the result of the reduction of tungsten trioxide by either carbon or hydrogen; powders of copper, chromium, iron, and nickel are produced by the reduction of their oxides, by gas or by electrolysis.

No matter which method of production is employed, the resulting powders must show certain definite physical and chemical characteristics in order to be suitable for use in powder metallurgy. One of the most important conditions is purity. Impurities introduce problems which (in an art where the science lags behind the practice) are not readily solved by the users of metal powders. Furthermore, with some metal powders, a clean surface of the particles is an absolute necessity in order to get ductility and tensile and shear strength in the finished part. The producers of powders have therefore paid particular attention to purity, which is generally well above 99 per cent. And in some cases, as in tungsten, tantalum or zirconium, to mention only three, a purity of 99.99 per cent is often found.

Next in importance to purity, the fabricator of metal parts looks for compressibility of the powders. . . .

Powders are now produced in angular, globular, acicular, nodular and other shapes, all of which are required by the fabricator for parts of one type or other. . . .

Apparent density is of the utmost importance and is frequently the deciding factor in establishing whether or not to apply powder metallurgy. . . .

Hardy pointed out that the influence of grain assortment upon all features of powder metallurgy is probably one of the most promising fields for further research.

Many applications and possibilities were listed by him. For example, small parts [very, very small, indeed] are now being produced at the rate of 4000 per min. Tolerances can be held in some cases as close as 0.001 in. and even less. Predetermined densities can be made and porosity can be controlled. Various combinations of metals, non-metals, and non-miscible metals are possible. Among the powder metallurgy parts displayed were gears, bearings, brass, steel, and aluminum parts, screens, filters, contact points, copper carbon brushes, radio parts.

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ARMY AIR FORCES PILOTS FLYING BELL AIRACOBRAS YOU HELPED TO MAKE SCORED 38 OUT OF 40 BOMB HITS IN ONE RAID ON JAP INSTALLATIONS DURING THE GUADALCANAL CAMPAIGN. IN THAT ATTACK TRACERS FROM ENEMY ANTI-AIRCRAFT GUNS "STOOD OUT LIKE SOLID STREAKS OF FLAME BUT THE AIRACOBRAS ROARING DOWN AT MORE THAN 400 MILES AN HOUR PRESENTED DIFFICULT TARGETS" THE REPORT TO THE WAR DEPARTMENT STATED. STRAFING THAT FOLLOWED THE BOMBING "WAS THE MOST BEAUTIFUL PART OF THE WHOLE SHOW" AIRACOBRA PILOTS WERE "ALL OVER ANTI-AIRCRAFT GUNS LIKE A SWARM OF HORNETS BLASTING AWAY WITH MACHINE GUNS AND CANNON. THE ENEMY GUNS WERE SILENCED IN SHORT ORDER" WORKERS IN HUNDREDS OF PLANTS PRODUCING PARTS ACCESSORIES SUB-ASSEMBLIES AND FINISHED AIRACOBRAS HELPED OUR PILOTS CRUSH THE JAPS IN THAT ATTACK. THE ARMY AIR FORCES ARE PROUD OF EVERY ONE OF YOU WHOSE SKILL AND WORKMANSHIP IN FACTORY OFFICE OR ENGINEERING LABORATORY HAD A PART IN PUTTING THOSE PLANES INTO ACTION
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THE QUICKEST, SUREST AND SAFEST WAY TO SEND MONEY IS BY TELEGRAPH OR CABLE

High-Strength Iron Parts

C. W. Balke in his paper included observations on the effect of pressure used in forming compacts from iron and steel powders through a pressure range up to 160 tons per sq. in. He pointed to the basic work done in tungsten which brought about the development of a powder metallurgy technique for its production and also referred to work on tantalum, but devoted most of his comments to the work on iron and steel powders in which field he had attempted to develop as many data of a fundamental nature as possible on pressed and sintered irons.

Considerable data were given in tabular form covering physical properties of electrolytic iron powder, and density and hardness of pressed and sintered electrolytic iron. One of the powders, for example, sintered at 1100 deg. C. (1830 deg. F.) for one hour, had a density range from 4.19 with a pressure of 5 tons per sq. in. up to 7.66 at the top pressure of 160 tons. At this top pressure, one of the powders with a tensile strength as pressed of 9500 lbs. per sq. in. developed a tensile strength on sintering at 1400 deg. C. (2550 deg. F.) for one hour of 41,600 lbs. per sq. in.; elongation in 2 in. of 30.5 per cent after sintering at 1100 deg. C. (2010 deg. F.)

Manganese-molybdenum steel was compared with a wrought product, the powder compact showing a greater tensile strength in the annealed condition than the wrought material and after hardening and quenching, the modulus of rupture was higher than the comparable product.

F. N. Rhines outlined studies involving process of alloying that takes place during the sintering and annealing of pressed metal powder compacts using a copper-nickel alloy series. In summary he stated that the tensile strength, elongation, hardness, linear dimensions and relative electrical resistivity of a 70 per cent Cu-30 per cent Ni powder alloy have been measured as functions of the powder size and the time of heat treatment. The mechanical and electrical properties, except elongation, reach maximum values before homogenization is completed and that this can be accounted for by a strategic distribution of alloy layers formed by diffusion. The rates of change of the mechanical properties appear not to be calculable by the simple relationships previously found adequate for predicting the rate of change of the electrical resistance.

A large amount of data and a number of curves and figures were offered by P. R. Kalischer on the effect of particle size on the shrinkage of metal compacts. As a powder compact is heated it should expand much after the fashion of a piece of wrought metal, and along with this expansion there should be associated a gradual compacting so that the integrated result would be a composite coefficient of thermal expansion somewhat lower for a powder compact than for wrought metal. If we were dealing with metals having no oxide films at all, and if we could flash them to the sintering temperature with no time lag, this assumption might perhaps be true.

Actually, however, a rather peculiar phenomenon takes place. If one plots the change in length versus temperature, he will find that for iron compacts made from relatively coarse powders (that is, powders coarser than 200 mesh) the behavior is very much as predicted. However, using particles finer than 200 mesh, at some temperatures well below the A_3, a break occurs in the expansion curve, and at this point the shrinkage of the compact is greater than the expansion due to increased temperature, with the net result that a knee is formed which is termed an "inflection temperature." As the particle size decreases, this inflection temperature likewise decreases.

In a summary curve Kalischer showed thermal expansion curves for iron, nickel, cobalt and silver compacts on — 325 mesh powders. Silver had the lowest inflection temperature about 440 deg. C. (825 deg. F.), followed by iron 550 deg. C. (1020 deg. F.), cobalt 695 deg. C. (1285 deg. F.), and nickel 735 deg. C. (1355 deg. F.).

The temperature of decomposition of the metal oxides seems to be a controlling factor. From the work thus far done, one can predict that iron oxide has a lower decomposition temperature under the same conditions than cobalt oxide, which in turn has a lower decomposition temperature than nickel oxide.

Cleaning in Aircraft Production

Condensed from "S.A.E. Journal"

Exposure tests made by the U. S. Army Air Corps to determine the relative adhesion of paints to 17ST, 24ST, and A24ST aluminum alloys after various chemical treatments and cleaning methods indicate that comparable results in paint adhesion will be obtained with either anodizing, chromatizing, or phosphatizing, and these methods are well ahead of ordinary cleaning methods before painting. This would appear to favor phosphatizing because the application of the phosphoric compound can be made to suit operating conditions and no special equipment is needed.

Aluminum and Magnesium

All soil, oil film, and residue should be completely removed from the metal before anodizing or chromatizing. In phosphatizing, light soil residues can be tolerated as they will be removed by the treatment. Precleaning, using emulsion degreasing, vapor degreasing, mechanical washing-machines, chemical vapor cleaners, or auxiliary hot tanks, saves much time and money.

Whether precleaners are used or not, a hot alkaline bath is required before the protective treatments. Compounds for this bath should not contain any fatty acids, soap-forming ingredients, or soap and must be inhibited properly against attack on the aluminum. The alkaline solution should be maintained at a pH well above 10.5. Efficiency of alkaline degreasing is increased by 100 per cent for each 20 deg. F. added above 120 deg. F.

The heating element should be placed at the front of the hot tanks so as to obtain a rolling action which gives a washing effect to the solution. Surface oil and scum are driven to the rear of the tank to avoid redeposition on the work.

Stripping of the anodic film from anodizing hooks, clamps, and springs before re-use can be done in one cold bath by adding "Nitro-Brite" to a nitric acid bright dip.

Mild alkaline compounds, properly inhibited against attack on aluminum, are generally not as safe on magnesium as the stronger alkaline compounds. Water affects magnesium, and in mild aqueous alkaline solutions, the time of submersion should be controlled to avoid etching. Increasing the alkalinity reduces the reaction from water and increases the safety factor.

Cocoa butter, which is frequently used as a mold lubricant for magnesium die castings, is best removed with an emulsion-type precleaner. Magnesium may be prepared by electrocleaning in the alkaline hot tank or by the straight hot alkaline bath without current. In electrocleaning, the work is made the cathode at 6-12 volts with a current-density of 10-30 amp. per sq. ft. of work.

Before Cadmium Plating

Successful cadmium plating of steel requires an absolutely chemically clean surface. Sulphur-bearing lubricants should be avoided, except where the severity of the forming operations demands them. Where possible, oils containing free fatty acids are usually favored, as saponification of the acid in the alkaline hot bath assists rapid removal. If the draw is not too severe, soluble drawing oils that are emulsifiable in water are recommended.

The alkaline hot bath should be kept above 180 deg. F. In electrocleaning, the work is made one electrical pole, and steel electrodes in the bath serve as the other pole. Best practice is to treat the work first cathodically to obtain maximum gassing and then to reverse the current for a few seconds to aid in removal of carbon smut and metallic impurities. The time of the anodic treatment must be insufficient for the metal to become roughened.

If the work is to be painted after cadmium plating, dipping in a dilute chromic acid or in a "Paintite" phosphatizing solution is advisable. Latter produces a slight etch with a fine matte to assure good paint adhesion. This phosphatizing treatment is also used for treatment of raw steel to passivate the surface, retard corrosion, and improve paint adhesion. The solutions employed on steel are generally of different compositions from the phosphatizing solutions used on aluminum alloys.

Cleaning for Spot Welding

In spot welding, all soil and oxides should be removed completely from the metal, and uniform condition of the metal surface from weld to weld is essential. Several methods are available for preparing metal for spot welding and opinions differ. One large aircraft manufacturer has greatly increased production and reduced man-hours by better lay-out and routing of work and installation of suitable cleaning compounds and equipment.

There are 5 tanks, all the same size, containing in order, alkaline solution, cold-water rinse, 3 per cent hydrofluoric acid solution, hot-water rinse, and hot-air drying-chamber. Electric timers are installed on the tanks requiring accurate control of time. The work is soaked for 5 min. in tank 1; rinsed in tank 2; etched in tank 3 for a period depending on metal thickness; rinsed in tank 2; soaked in tank 1; rinsed in tank 2 (last two operations are repeated if necessary), rinsed in tank 4; and dried in tank 5.

As some object to the use of hydrofluoric acid, there has been developed a phosphoric compound, designated "Koldweld," which contains no aggressively active acid or virulent poison. Use of this compound consists of a single cold dip, eliminating the hot alkaline solution.

Another development is a compound in jelly form for treating sections too large to submerge in solution, to be painted in a stripe over the area to be welded. After about a minute, the compound is wiped off with cloths dampened with clear water, and the parts are spot welded.

—Ray Sanders, *S.A.E. Journal*, Vol. 51, Jan. 1943, Trans., pp. 23-30.

Materials and Engineering Design

Engineering Properties of Metals and Alloys • Resistance to Corrosion, Wear, Fatigue, Creep, etc. • Engineering Design Problems of Specific Industries and Products • Selection of Metals, Metal-Forms and Fabricating Methods • Non-Metallics in the Metal Industries • Applications of Individual Materials • Conservation and Substitution

CONTENTS

Riveted vs. Welded Structures

Condensed from "University of Illinois Bulletin"

The properties of 3 low-alloy steels, and the behavior of structural joints, riveted and welded, fabricated of these steels, were investigated and determined. The steels had the average compositions seen in the table. Test methods and test apparatus are described in detail.

TEST METHODS AND TEST APPARATUS ARE DESCRIBED IN DETAIL

Class	Form	C	Mn	P	S	Si	Cu	Ni	Cr
A	plates	0.202	0.472	0.009	0.032	0.056	0.78	1.862	
	rivets	0.169	0.512	0.009	0.033	0.013	0.89	1.840	
B	plates	0.103	0.423	0.089	0.036	0.338	0.41	0.533	0.695
	rivets	0.088	0.371	0.093	0.031	0.307	0.38	0.550	0.784
C	plates	0.225	1.352	0.016	0.031	0.168	0.31	0.572	
	rivets	0.210	1.470	0.013	0.031	0.184	0.25	0.520	

Summary of Results

The very exhaustive results can be summarized as follows: The initial tension in the rivets was somewhat erratic, but increased with the grip from below 13,000 lbs. per sq. in. for a grip of 2 in. to as high as 40,000 lbs. per sq. in. for a grip of 5 in. In general, the tension was somewhat greater for short rivets (2-in. grip) driven with a pneumatic hand riveting hammer than for those driven with a hydraulic riveting machine; for the initial tension was less for rivets of low alloy carbon than for steels A and B.

The unit tensile strength was appreciably greater for the driven than for the undriven rivets, the strength being 29 per cent greater for the former than the latter for the alloy steel B rivets with a 3-in. grip driven with a hydraulic riveting machine. The increase in strength due to driving was, in general, greater for rivets driven with the hydraulic riveting machine than for those driven with the pneumatic hand riveting hammer. In all cases, however, increase in strength of the rivets was accompanied by some reduction of their ductility, but no brittle fractures for any of the driven rivets tested in tension occurred.

The ratio of strength in single shear to strength in tension was 0.67, 0.73 and 0.69 for the undriven A, B, C rivets, respectively, and 0.65, 0.69, 0.66, respectively, in double shear; the ratio of single shear strength of machine driven rivets to that of undriven rivets was 1.13, 1.15, 1.18, respectively. Rivets with a 5 in. grip, in general, filled the holes just beneath the head but did not completely fill the holes in the middle. The completeness with which the rivets filled the holes was not related to either the method of driving or the kind of steel.

Minimum Shear

The minimum shear that produced an appreciable slip was smaller for short than for long rivets. The minimum shear that produced an appreciable slip increased with the rivet material in the order C, B, A, but the increase was not large. Only three of the specimens with butt welds in the as-welded condition broke outside of the welds, but the low alloy steel A and B specimens which broke in the weld showed as great a strength as similar plates without joints.

Steel C specimens, all of which broke in the weld, developed an average strength of 80,400 lbs. per sq. in., 92 per cent of the strength of similar plates without joints. Specimens with butt welds ground flush with the base plates on both sides all broke in the weld. A and B specimens developed almost as great a strength as the similar plates without welds, but C specimens had an average strength of only 72,200 lbs. per sq. in., 83 per cent of the strength of similar plates without joints.

Increase in Hardness

The increase in hardness associated with driving the alloy steel rivets examined was caused by plastic deformation producing grain refinement at temperatures low enough for work hardening, and by rapid cooling with attendant highly dispersed carbide


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precipitation. These factors would tend to improve the strength and toughness in hardened areas where they were effective.

In no case was the cooling rate sufficiently rapid to form a hard, brittle martensitic structure. The increase in hardness in the heat-affected zone of the butt welds in the alloy steels which were examined was not excessive for A and B. The fracture of the low-alloy steel C specimens showed small corroded areas when failure occurred, indicating the presence of cracks due to excessive hardening, but the evidence as to the hardness of the region of the crack at the time of its formation was obliterated by subsequent reheating during welding.

—W. M. Wilson, W. H. Buckner & Th. H. McCrackin, *Univ. of Illinois Bulletin*, Vol. 40, Sept. 22, 1942, pp. 1-73.

Cast Irons for High Temperatures

Condensed from a Report of Meeting of Amer. Soc. for Testing Materials

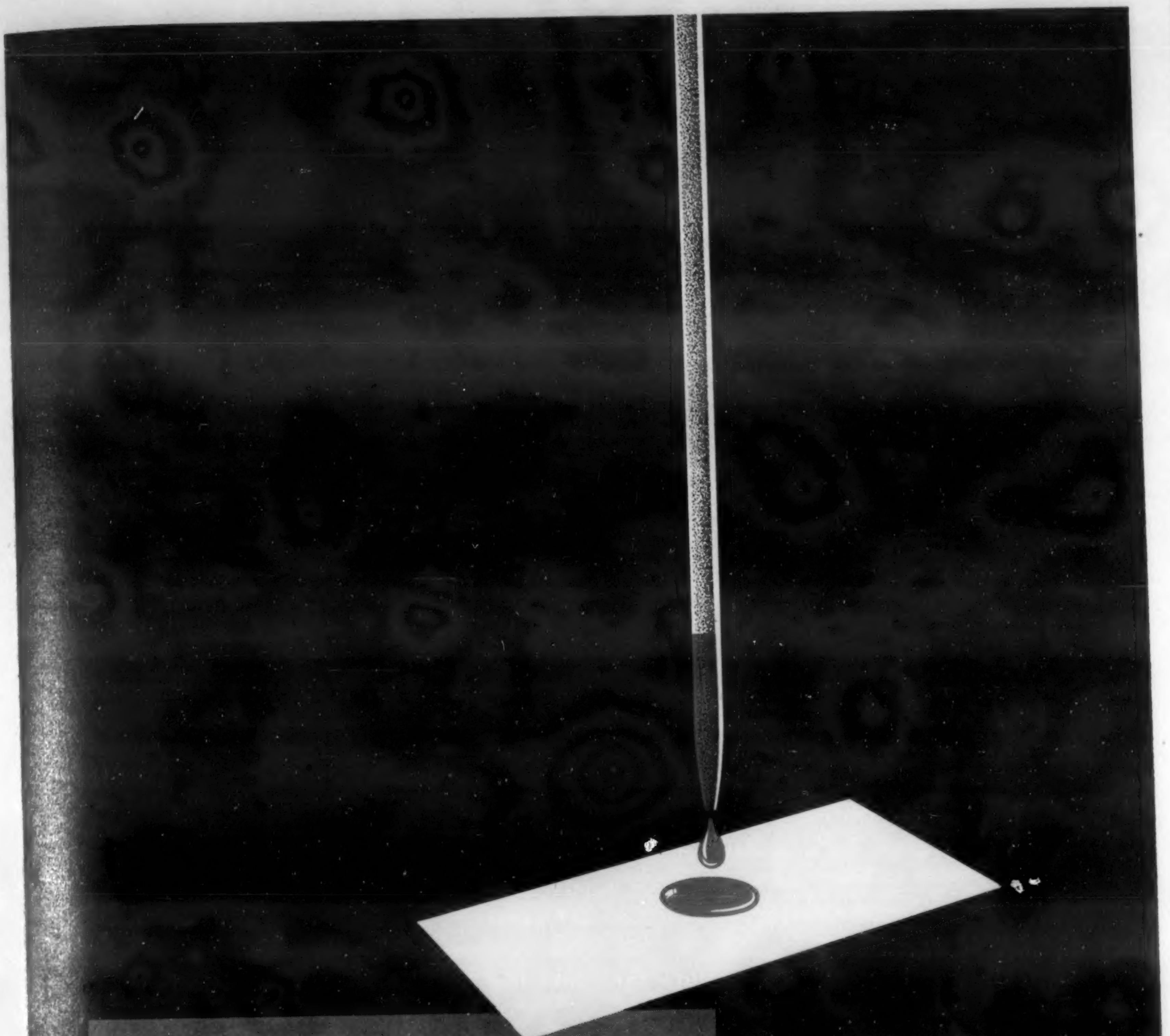
Members of this committee assembled for their initial meeting. Members of the American Foundrymen's Association committee on the same subject were invited to attend. Some 35 to 40 representatives of all groups were present. The origin of the committee, which was formed by resolution passed at the June 1942 Annual A.S.T.M. meeting, was described, and the events that followed, leading up to co-operation from the American Foundrymen's Association. Simultaneously, the interest of the Government in utilizing the productive capacity of the foundry industry for making cast iron equipment, led to a study of the subject by the War Metallurgy Committee.

The main feature of the meeting centered about a discussion of the assembled opinion of representatives of various manufacturing interests who employ cast iron at elevated temperatures, and a preliminary report upon the findings of the War Metallurgical Committee was presented. The report classified its findings into four temperature ranges covering applications from:

Deg. F.	Pressure vessels
450 to 600	Pressure vessels
600 to 750	Engine and firebox castings
750 to 1000	Engine and firebox castings
Over 1000	

The discussion revealed that the application of cast iron to pressure vessels had not been surveyed since 1914, and at that time cast iron with a tensile strength of 20,000 lbs. per sq. in. was considered of good quality. The 1914 survey revealed that no trouble had been experienced in pressure applications operating under 450 deg. F. and 150 lbs. pressure, and these limits were naturally accepted. The comments at the time indicated that if a 30,000-lb. iron had been available higher temperatures and pressures would have been allowed.

Since that time, the strength of cast iron has been more than doubled. The War Metallurgy Committee's report revealed that many pressure applications operate successfully at temperatures above 450 deg.



F. They also revealed that in the higher temperature ranges cast irons are correspondingly high quality types, and more than 50 per cent of that represented processed or inoculated cast irons of the latest metallurgical high grade types.

The A.S.T.M. committee expects to receive a summary of the War Metallurgy Committee's reports by the middle or end of April, and to add as much new information as possible to the study so that such further review as is possible can again be made during the annual meeting of the American Foundrymen's Association in St. Louis, Mo., April 28 to 30, at which time Committee A-3 of A.S.T.M. on Cast Iron will hold additional meetings.

Representatives of various industrial groups at the Buffalo meeting expressed the opinion of their industries regarding the properties and performance of cast iron under the conditions which their equipment encounters in service. There were comments concerning design factors which limited manufacture in the foundry to specific types of castings; other comments concerning the over-design of parts such as valve castings, which might be readjusted by dividing designs into large and small diameter members.

Further comments on stress concentration in pressure castings and upon heat transfer in direct fired vessels, which were under little or no pressure, were made. There was some mention of the need for extreme care in turbine construction. Others mentioned the favorable performance of cast iron in steam or hot gases under dry wear conditions.

It is the purpose of the committee to assemble these data and review them. It is then the plan to (1) discharge the work of the committee by summarizing the information available on specific industrial applications, (2) analyzing the data with a view toward defining the quality and capacity of cast iron for elevated temperature service, and (3) recommending problems in connection with this work which require further study.

—Report of Meeting of *A.S.T.M. A-3 Subcommittee,* Buffalo, N. Y., Mar. 2, 1943.

Steam Corrosion of Alloy Steel

Condensed from "Transactions," Amer. Soc. of Mechanical Engineers

Apparatus and methods are described for measuring the amount of corrosion on stressed specimens of C-Mo, 1.25 per cent Cr-Mo, 2 per cent Cr-Mo, 7 per cent Cr-Mo, 9 per cent Cr-Mo and 18 and 8 per cent stainless steel for high-temperature service. The following conclusions were reached:

(1) The results of 1030 and 2000-hr. tests indicate that the stress, within the ranges of time, temperature, and stress used, does not influence the penetration or corrosion due to high-temperature steam for the steel tested.

(2) No intergranular attack took place except for a small amount in the case of carbon-molybdenum steel in the 2000-hr. test.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(3) Chromium-content increases the resistance of steels to corrosion by high-temperature steam.

(4) The 18-8 stainless steel is extremely resistant to steam corrosion.

The load consisted in all cases in tensile load.

—H. L. Solberg, A. A. Potter, G. A. Hawkins & J. T. Agnew, *Trans. Am. Soc. Mech. Eng.*, Vol. 65, Jan. 1943, pp. 47-52.

German Substitutes for Tin Plate

Condensed from "Stahl u. Eisen"

In the last war, lacquer was applied direct to black sheet as a substitute for tin plate to be used for tin cans. It was unsatisfactory since it is very difficult to have the lacquer adhere firmly and have no pores through which corrosion could start. Moreover, the lacquering can not be done at the rolling mills due to the possibility of damage in transit.

In this war, use is being made of bonderized and lacquered cans, made from both hot rolled and cold rolled sheet, and treated in the sheet metal works after beading the bottom.

A bonderized coating consists of a tertiary zinc phosphate with a few per cent of secondary and tertiary ferrophosphates. The process of bonderizing roughens the metallic surface, so organic materials adhere very strongly to it. The coating has 0.3 to 0.5 per cent pores, so it is not corrosion resistant unless subjected to a finishing process (i.e. lacquering); in that case, it causes a marked increase in corrosion resistance. With a single lacquer coating, a thin, fine, crystalline phosphate is more satisfactory than a thick coating.

Deformability of the Coating

The phosphate layer is less ductile than the metal. However, experiments with a thin bonderized coating (0.003 mm.), lacquered, showed satisfactory results in regard to deformability if the right kind of lacquer was used (no indication as to composition). Thicker bonderized coatings (0.01 mm.), lacquered, lead to lower deformability.

An impact test designed to test the relative resistance to denting of filled cans showed similar results. (In these tests the perforation of the coating was measured by the Niesen-Röhrs method. An AC voltage of 10 is set up between the lacquered sheet and an electrode in a cell with a liquid conductor. If there are no pores on the sheet, then no current flows. As pores are formed, a current flows which increases with the increasing exposed area of the sheet).

Salt spray tests (3% NaCl) showed the bonderized and lacquered sheet to be better than either bare or sanded sheets lacquered with the same lacquers. There was considerable difference among the lacquers (again no composition given). Various "autoclave" tests (½-kg. can boiled at 120 deg. C. (248 deg. F.) for 30 min.) were made in 0.5 per cent lactic acid and 3 per cent NaCl. Although

the lacquer adheres better to the sanded surface than to the bare, partial peeling is observed and the behavior towards the reagents is not as good as that of the bonderized sheets.

Stove dried artificial resin lacquers are practically the only ones now being used. Drying temperatures are mainly above 180 deg. C. (356 deg. F.). Most can lacquers are either phenol or alkyl resins or mixtures; all have satisfactory resistance to boiling and stability to exposure of water. While there is a difference in the behavior of different lacquers, yet in any case the resistance to corrosion is much improved by the underlying bonderized coating.

Bonderized Cans

Rapid strides have been made in the industrial production of bonderized cans since 1937. Automatic machinery has been produced to weld the cans in place of the formerly standard soldering. Butt welding saves about 165 kg. of sheet per 100,000 cans, since the overlap required on soldered cans is eliminated. Cold rolled strip readily takes a phosphate coating. The Züchner plant, the first for bonderizing and lacquering cans, has a production of 5,000 to 6,000 cans per hr.

Various foodstuffs were canned in bonderized and lacquered cans and stored at 37 deg. C. (98.6 deg. F.) for a year. Both meat and vegetables were found to be well preserved, but fruits were less well preserved than in tin cans. It is believed that future development of the bonderized can will reduce itself to a solution of the problem of finding the best lacquer. Also, if the bottoms of cans could also be welded in, there would be a further saving in the amount of material per can as well as an elimination of the corrosion which occurs at the end folds.

—L. Schuster, *Stahl u. Eisen*, Aug. 13, 1942; as translated by E. R. Francis, *Sheet Metal Ind.*, Vol. 16, Dec. 1942, pp. 1859-1860; 1865; Vol. 17, Jan. 1943, pp. 83-84.

High-Temperature Wear Resistance

Condensed from "Archiv Eisenhüttenwesen"

Unalloyed steels with 0.04 to 0073 per cent C, cast iron, non-rusting chromium and chromium-nickel steels and manganese hard steel were investigated in a special arrangement for purely gliding metallic friction under particular consideration of the effect of heat in the range from —190 to +700 deg. C. (—310 to +1300 deg. F.) and with gliding velocities of 1.8 and 9.5 in. per sec.

Wear occurred in 3 different forms: 1. Formation of flakes, 2. carrying away of flow layers, and 3. oxidic abrasion. The first case caused high wear due to immediate contact and mutual reaction of the two metals gliding on each other. Increased heating reduced wear. Flow layers presuppose high temperatures in the outer layers of the two metals, either produced by the friction or supplied artificially.

Wear hereby was high if the almost always existing oxide film was destroyed, and low if the flow layer moves under the intact oxide film and can escape on the side. Oxidic abrasion is connected with high temperatures and simultaneous little deformation in the gliding plane. All three forms occur together.

The effect of different lubricating liquids on the wear of unalloyed steel with 0.10 per cent C (both gliding parts) is shown in the following table:

Liquid	Viscosity, Engler	Loss of weight in g. at a gliding velocity of in. per sec.	
		1.8	9.5
Liquid air	1.20	3.400	0.020
Water	1.00	17.585	0.288
Solution of 3% H_2O_2 in water	1.00	16.250	0.515
Burning alcohol	1.06	14.280	8.055
Benzin	0.90	10.300	0.365
Solution of 25% NaCl in water	1.10	0.038	0.127
Solution of 10% sugar in water	1.10	0.023	0.122
Solution of 10% waterglass in water	1.87	0.287	0.009
Solution of 10% soap in water	1.04	0.000	0.080
Solution of 1% soap in water	1.00	0.038	0.081
Emulsion of 4% drilling oil in water	1.03	0.000	0.000
Petroleum	1.12	0.000	0.009

Curves show the connection between temperature, load and gliding velocity; some of the results confirm observations already known.

—W. Rädeker, *Arch. Eisenhüttenw.* Vol. 15, May 1942, pp. 453-466.

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CONTENTS

Salt Spray vs. Seawater Testing

Condensed from "Proceedings," Amer. Electroplaters' Society

Much work has been done in the past few years on the standardization of the salt spray test. Some of the variables involved in salt spray testing are temperature, spray solution concentration, pH of the solution, fog density, manner of impingement of the spray, and the position of specimens.

Non-uniformity of the above conditions in salt spray tests applied by different laboratories has resulted in varying results and a need for standardization is apparent. As a result of this situation the Chrysler corporation has started work on a standardization of the salt spray procedure. Results of the work done so far are reported in this paper.

Objects of the Tests

The objects of the present work are: (1) To correlate the results of the salt spray test with results obtained in outdoor exposure tests in an industrial atmosphere; (2) to correlate the results of the ocean spray test with salt spray and industrial atmosphere exposure tests; (3) to standardize the procedure for salt spray testing using a large spray room; (4) to study the effect of temperature on the results of salt spray testing; (5) to study the products of certain nickel baths under these various conditions.

The design of the apparatus used and the operating conditions are described in detail. Panels were supported in racks at an angle of 30 deg. from the vertical. The salt spray solution concentration was 20 per cent. The ocean spray solution was sea water from near Wilmington, N. C. Temperatures used were 72 and 95 deg. F.

The results showed that, in general, bright nickel deposits from one type of bright nickel bath were about equal in protective value to nickel deposits from a Watts bath. Nickel deposits from another type of bright nickel bath were in general inferior.

Approximately parallel results were obtained whether the ratings were based on the time elapsed before initial failure, or on the condition of the panels at the termination of the test. In general, panels with nickel plus chromium rated better than panels with nickel alone, in the salt spray tests. This has been observed by other investigators.

The tests, as would be expected, were more severe at the higher temperature. However, with the 20 per cent salt spray the difference was slight, whereas with ocean spray, the increase in the severity of the test at 95 deg. F. was marked.

Sea Spray More Corrosive

Ocean spray, in general, proved to be more corrosive than the 20 per cent salt spray. An explanation proposed for these effects is based on the greater solubility of air in the ocean spray than in the 20 per cent salt spray.

With regard to time of initial failure, there is no correlation between the salt spray tests and outdoor exposure tests.

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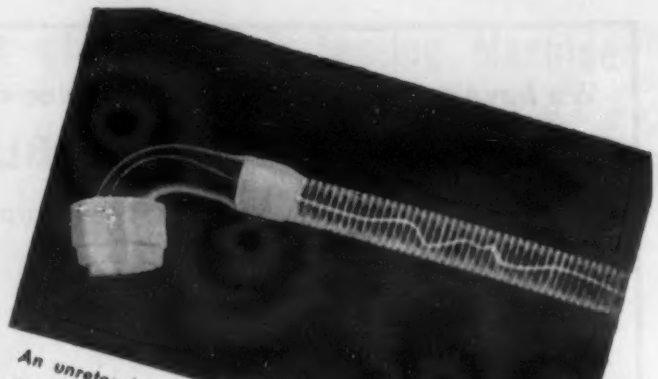

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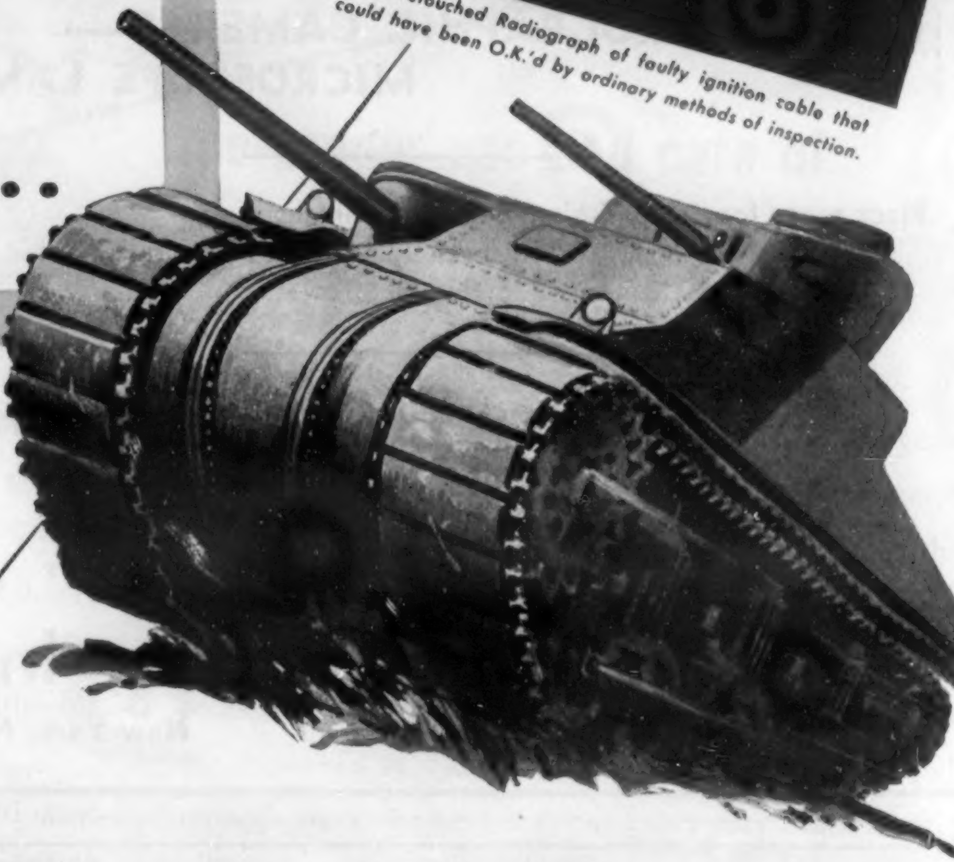

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to protect the base metal in outdoor tests, and in some cases it hastened failure. Parallel results are obtained based on the condition of the panels at the termination of the roof exposure. However, even though the chromium accelerated the failure, it did preserve a brighter more decorative finish, whereas panels with nickel only were covered with a heavy blackish-green deposit. In this respect there is a correlation between the salt spray and roof-exposure tests. With both types of test, increase in deposit thickness increases corrosion resistance.

It is concluded that the 20 per cent salt spray is preferable to ocean spray for practical testing, because of the smaller influence of temperature on the former, and because it is already a widely used standard.

C. E. Heussner, *Proc. Am. Electroplaters' Soc.*, 1942, pp. 75-88.

Diagram of Nitrogen-Bearing Steels

Condensed from "Archiv Eisenhüttenwesen"

The addition of nitrogen to chromium steels with more than 18 per cent Cr gives in casting alloys a better structure, a lesser grain coarsening in welding and better toughness after annealing at high temperatures. Austenitic chromium-manganese steels with nitrogen have higher elastic limit and elongation, and higher strength at high temperatures and creep strength than nitrogen-free steels.

Chromium-nitrogen steels can, in general, be produced by saturating carbon-poor ferrochromium with ammonia at 700-900 deg. C. (1300 to 1650 deg. F.) nitriding temperature; ferrochromium is added to the steel melt after the greater part of the chromium has dissolved. The obtainable nitrogen contents in the steel amount to about 1/75 of the chromium content.

Tests were made with 17 iron-chromium-nitrogen alloys dilatometrically, magnetically, microscopically and with X-rays; on the basis of these results a section through the iron corner of the diagram iron-chromium-nitrogen was developed for a ratio of 75:1 for chromium-nitrogen. The γ-range and the γ-α miscibility gap are considerably enlarged by nitrogen.

With the nitrogen contents as used in the experiments, only alloys with more than 30 per cent Cr become purely ferritic. Over 35 steels with 10 to 35 Cr, 2 to 23 Mn and 0.11 to 0.44 per cent N were investigated, in quenched and partly annealed condition at different temperatures, with regard to hardness, notch-impact toughness, magnetically, microscopically and by X-rays, from which the phase borders are developed for steels in quenched condition and annealed at 700 deg. C. (1300 deg. F.).

Nitrogen enlarges in chromium-manganese steels the range of austenitic permanency and shifts the limits for the occurrence of the brittle σ-phase to slightly higher chromium contents.

—H. Krainer & O. Mirt, *Arch. Eisenhüttenw.*, Vol. 15, Apr. 1942, pp. 467-472.

Number 1 of a series covering use and maintenance of Southwark Testing Machines

War Service Memo: *To users of Southwark testing machines*

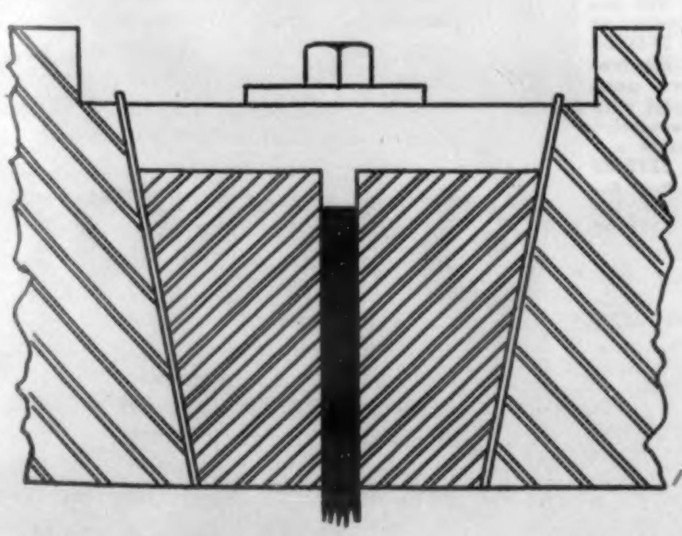
the proper use and care of

Grips

Here are a few suggestions that will enable you to extend the life of grips and eliminate one of the primary sources of trouble in physical testing.

Grips are especially designed for handling various shapes and types of specimens. Always use the proper grips for each specimen. Use "V"-grips for rounds and flat grips for flat specimens.

In selecting proper grips, the material to be tested must be considered. For example, round bars of soft steel or brass up to about ½-in. diameter can be safely tested with flat wedge grips, whereas, spring temper or hard drawn wire only ⅛-in. diameter would damage flat-face grips. For materials such as music wire, special grips with renewable file faces are recommended.



Remember that in the interest of strength and toughness, the ordinary wedge grip—either flat or "V"—cannot be made as hard as a file. Occasionally it may be necessary to make tests on materials harder than the grips. In this case an old set of grips should be used.

Before a specimen is pulled, the double pinion gears used for moving the grips in the slots should be centered and anchored in place with the set bolts. Otherwise the specimen will not be centered and may not be pulled straight.

Sufficient liners should be used, of the same thickness on both sides of each grip, so that the grips are well within the crosshead of the machine. If one or both grips pull through when the load is applied they may break or they will upset the corners of the crosshead casting and are likely to damage the double pinions.

Test specimens should extend at least ¾ of the length of the grips.

When grips do not move smoothly in the heads, as revealed by a clicking noise and a jump on the load indicator, a lubricant should be used on the back of the grips. Any grease used to lubricate lathe centers is satisfactory. White lead in oil is frequently used. Use only a small amount—and only on the backs—or it will collect scale and dirt.

Always use grips retainer furnished for bolting to crosshead castings, otherwise recoil may throw the grips out of the machine.

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Micro-Hardness Tests

Condensed from "Zeit. f. Metallkunde"

The usual method employed in diffusion studies where successive thin layers of metal in the diffusion zone are machined off and analyzed has been modified by Bückle by making microhardness determinations instead of chemical analyses. The Hanemann-Bernhardt microhardness tester was employed.

Bückle used a constant load because of the necessity of using only one impression at a single point in the diffusion zone. In studying the diffusion of copper into aluminum, 99.998 per cent Al was used with a 4 per cent Cu alloy made with the high purity aluminum.

Samples were in the form of cylinders 5 mm. dia. and 6 mm. high electrolytically polished, and clamped together in a steel holder. Diffusion treatment was carried out in a high vacuum at 500, 515 and 550 deg. C. (932, 959 and 1022 deg. F.) for 22 hrs. After this treatment, the specimens were solution treated at the diffusion temperature for 15 min., water quenched, and room temperature aged for 5 days. Before testing, the samples were electrolytically polished to obviate work hardening.

Microhardness tests were then made along the diffusion direction at the smallest possible intervals. An average of several series of hardness measurements resulted in diffusion curves of the usual form.

Plots were also made of the variation of the diffusion constants with temperature. An interesting feature was the linear relationship between the microhardness and the concentration of copper in aluminum. When the solid solubility was exceeded, the hardness became constant, hence the form of the curves were closely similar to a plot of lattice constant vs. concentration. It is estimated that the hardness values are correct to within ± 6 per cent.

Bückle's plot of the diffusion constant vs. the reciprocal of the absolute temperature is in good agreement with the results of Brick and Phillips who used microscopic methods. Perhaps the main drawback of Bückle's method is that it is an indirect one, and depends upon a definite and reproducible relation between hardness and concentration.

Then, too, the hardness method can only take account of the end results of diffusion phenomena and gives no information on the precise cause of the reactions involved. It is a new method as applied to diffusion studies, and should be used in conjunction with more direct methods.

—Bückle, *Zeit. f. Metallkunde*, Vol. 34, 1942, p. 130, abstracted in *Light Metals*, Vol. 5, Dec. 1942, pp. 510-513.

Method of Recording Macrostructures

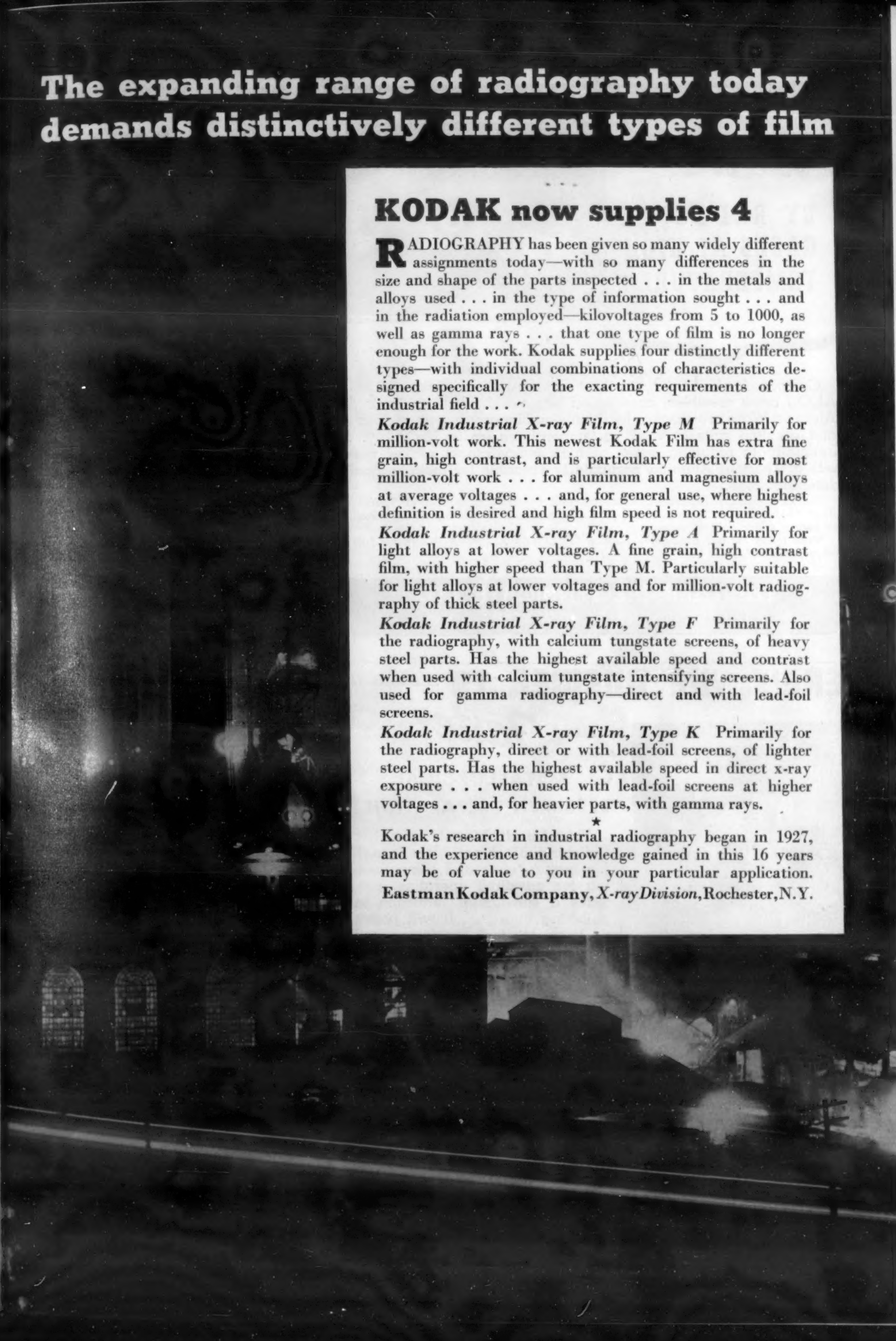
Condensed from "Engineering"

Due to the shortcomings of the various methods of reproducing macrostructures the writer carried out experimental work on a method which so far has not been used.

The method can be applied successfully to any material which can be etched so as to produce a relief effect sufficient to enable a satisfactory negative ink impression to be obtained, and the resulting illustration appears to be suitable for use in many cases where a photograph was formerly necessary.

It is advisable to prepare the specimen as if it were intended for microscopic examination. The surface should be rubbed down on abrasive paper. When a good surface finish has been obtained, the specimen is washed with soap and water and dried. The etching reagent is a solution of copper-ammonium-chloride acidified with hydrochloric acid. This reagent deposits a film of copper which is strongly adherent. Neutral solution is made by dissolving 120 gms. of copper-ammonium-chloride in 1000 cc. of water.

The best method of using the reagent is as follows: The surface of the specimen is rubbed with cotton wool which has been dipped in a neutral solution and, as soon as attacked by the solution, the specimen is immersed face downwards into the neutral solution for a few seconds. Next it is rinsed in water and the copper film rubbed off with cotton wool. If the film comes off easily the specimen is re-immersed in the solution and transferred without rins-



The expanding range of radiography today demands distinctively different types of film

KODAK now supplies 4

RADIOGRAPHY has been given so many widely different assignments today—with so many differences in the size and shape of the parts inspected . . . in the metals and alloys used . . . in the type of information sought . . . and in the radiation employed—kilovoltages from 5 to 1000, as well as gamma rays . . . that one type of film is no longer enough for the work. Kodak supplies four distinctly different types—with individual combinations of characteristics designed specifically for the exacting requirements of the industrial field . . .

Kodak Industrial X-ray Film, Type M Primarily for million-volt work. This newest Kodak Film has extra fine grain, high contrast, and is particularly effective for most million-volt work . . . for aluminum and magnesium alloys at average voltages . . . and, for general use, where highest definition is desired and high film speed is not required.

Kodak Industrial X-ray Film, Type A Primarily for light alloys at lower voltages. A fine grain, high contrast film, with higher speed than Type M. Particularly suitable for light alloys at lower voltages and for million-volt radiography of thick steel parts.

Kodak Industrial X-ray Film, Type F Primarily for the radiography, with calcium tungstate screens, of heavy steel parts. Has the highest available speed and contrast when used with calcium tungstate intensifying screens. Also used for gamma radiography—direct and with lead-foil screens.

Kodak Industrial X-ray Film, Type K Primarily for the radiography, direct or with lead-foil screens, of lighter steel parts. Has the highest available speed in direct x-ray exposure . . . when used with lead-foil screens at higher voltages . . . and, for heavier parts, with gamma rays.

★

Kodak's research in industrial radiography began in 1927, and the experience and knowledge gained in this 16 years may be of value to you in your particular application.

Eastman Kodak Company, ***X-ray Division,*** **Rochester, N.Y.**

ing to the acid solution, but if it shows signs of adhering strongly the specimen should be refaced on No. 0 paper until all traces of copper have been removed. Prolonged etching in neutral solution is not advised. As soon as an even non-adherent copper film has been obtained in the neutral solution, the etching is carried out in the acid solution. Acid etching time varies from 15 to 45 min. When the surface shows a pronounced roughened appearance, etching is completed.

Next the specimen is washed with water and the copper film removed with cotton wool. After drying, a trial ink impression is taken. If the depth of etch is insufficient, the specimen should be well cleaned and subjected to full etching procedure.

Of the various materials tried on which to make negative impressions, cellophane proved the most suitable. The backing pad for the cellophane should consist of an ordinary writing block ½ in. thick laid on a flat surface and between the leaves of this is placed a sheet of thin brass. On top of the block is placed a sheet of smooth rubber about 0.020 in. thick.

Printers ink is placed on an ink plate and distributed evenly over the plate by means of a composition roller. In making the ink impression a considerable amount of pressure is required.

If the impression shows varying shades of gray, the print is satisfactory and the cellophane may be peeled off so the ink impression may be examined.

—G. A. Cottell, *Engineering*, Vol. 155, Jan. 29, 1943, pp. 81-83.

Stress Measurement with X-ray

Condensed from "Mitt. Kaiser-Wilhelm-Inst. Eisenforschung"

While the determination of interior stresses in single crystals is comparatively simple by comparing the elasticity coefficients thus found with those observed with mechanical instruments, the determination is not quite so simple in polycrystalline pieces, as in the latter case the mechanical determination gives the average of the stresses over many crystallites.

A different method of evaluation must therefore be applied. This is explained by the example of the determination of tensile and bending stresses by mechanical determination and X-ray radiation (from cobalt and chromium).

It is shown that in the X-ray test other elasticity coefficients have to be used than those found from the normal values. The former coefficients depend on the planes in which the X-ray determinations were made.

The deviation from the mechanical values is considerably greater for the (310) planes of the iron than for the (211) planes. All observed elasticity coefficients, both mechanical and X-ray, can be considered as average values of those that can be calculated exactly by the method of Voigt and Reuss.

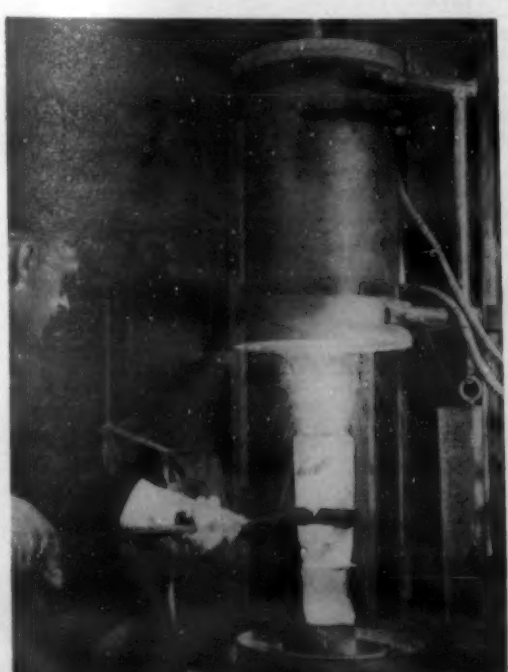
—H. Neerfeld. *Mitt. Kaiser-Wilhelm-Inst. Eisenforschung Düsseldorf*, Vol. 24, No. 6, 1942, pp. 61-70.

METALLURGICAL ENGINEERING news

Equipment • Finishes • Materials • Methods • Processes • Products
Alloys • Applications • Designs • People • Plants • Societies

Tiny Mill for Electronic Alloy

What is termed a "baby steel mill" turns out ingots of "Kovar" (30 per cent nickel, 15 per cent cobalt, remainder iron) weighing 13 lbs., which are used by a thermometer manufacturer to produce temperature gages for bomber and fighter planes. The "mill" is a tiny electric furnace, developed by *Westinghouse* engineers. After each ingot cools, it is



forged into a rod, with samples closely checked for resistance values.

Kovar can be drawn into a delicate wire two-thirds as thick as a human hair, and was developed by Westinghouse originally as a metal sealer for electronic tubes. The thermometer maker adapted it to measure the heat in airplane engines and wings.

Made in large batches in regular Westinghouse production furnaces, the resistance properties of the metal are ordinarily not important. But to the thermometer concern the resistance of the alloy, particularly the way the resistance increases as the metal gets hotter, is vital.

● A new war-time rough metal finish, "Pebble-Tex," has been brought out by the *Egyptian Lacquer Mfg. Co.*, 1270 Sixth Ave., New York. It is adapted particularly for parts to be used in radio equipment for military use, instrument panels, fire control and listening devices. It is usually applied over a primer.

New Magnesium Metal Plant

Dow Magnesium Corp. poured its first metal in the fifth Dow-process plant built by the *Austin Co.* for the *Defense Plant Corp.* "somewhere in Michigan" on April 8. When in full production it will equal the largest of its kind. Electric current flows through huge bus bars of solid silver, which almost completely replaces copper in the power distribution lines and which was loaned by the Government.

The start of magnesium production anticipates the early beginning of operations at Dow's companion plant across the state. There, magnesium chloride for use in the eastern Michigan plant will be produced from subterranean salt brine by the method inaugurated by Dow at Midland, Mich. over 26 years ago. This cell feed will be transported across the state in covered gondola cars to the new plant, which was located with reference to availability of power.

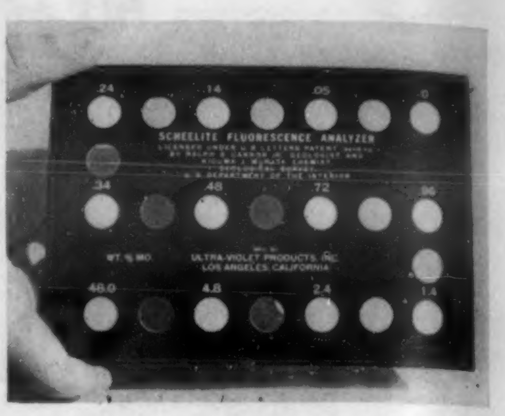
In the accompanying photograph, Dr.

Willard Dow, president of the Dow Chemical Co., looks on as an employee pours the first ingot.

● "Tulox TT" seamless plastic tubing is now available in all diameters up to 2½ in. O.D. It is made by *Extruded Plastics, Inc.*, Norwalk, Conn., from Tennessee Eastman cellulose acetate butyrate.

Aid for Molybdenum Content Determination

A scheelite fluorescence analyzer card is designed for use with ultra-violet "black light" mining lamps. It makes possible instant comparison of ore samples with standard type scheelite examples to determine percentage of molybdenum content. The



card carries 12 fluorescent checking examples, each ½ in. in diam., illustrating 12 molybdenum content gradations from 0 to 48 per cent.

Adjacent to each is a hole so that a sample of the ore to be tested may be placed beside the test example and examined under ultra-violet light to determine the value. Molybdenum content can be estimated easily and quickly within a negligible variation. It is produced by *Ultra-Violet Products, Inc.*, 5205 Santa Monica Blvd., Los Angeles.

● A new Thyratron tube with both a control and shield grid for control applications is announced by *General Electric Co.*, Schenectady. This GL-502 tube is a bit over 2½ in. long, weighs 2 oz., is inert-gas filled and of all-metal construction. Applications will be found in industrial welding and any general control equipment. It is for use where weight and space must be considered.

Improved Spring Stripping Units

New improved Strippits (spring stripping units) have been announced by *Wales-Strippit Corp.* No. Tonawanda, N. Y. They allow the removal and replacement of the stripper plate without taking the die cut of the press or disturbing any part of the set-up.

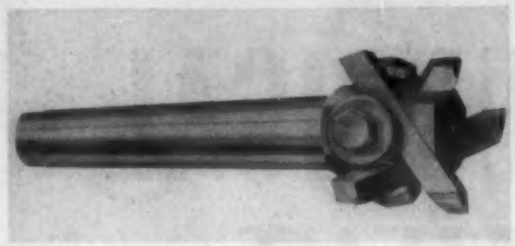
Dulled or broken punches can be replaced without disturbance. Equal pressure is provided around the entire stripper plate by the uniform pressure of every Strippit.

They eliminate the usual spring grinding, stripper bolts, drilling and counterboring for stripper bolts and boring spring pockets. They are self-contained, self-aligning units in which the built-in spring is held compressed by a retainer and assembly link.

One end has a screw thread that holds the Strippit to punch or die shoes; the other end has a tapped hole for screw to hold stripper plate to the Strippit. They are available in lengths from 2½ to 6 in.

Three-Blade Tool for Surface Facing

An adjustable tool for efficient surface facing in horizontal or vertical milling machines, lathes and other spindle machines is announced by *Robert H. Clark Co.*, 3424 Sunset Boulevard, Los Angeles. It consists of a tapered (or straight) shank and body with three adjustable high-speed bits, which may be set for any diameter within the range of the tool.



It is useful for dressing castings of any metal, dovetailing, spot facing, as an emergency repair tool and many other end mill, facing mill or slab mill operations. A measuring gage is provided with each tool for quick and accurate size adjustments.

The bits can be easily reground or can be replaced with new bits at comparatively small cost.

● A new all-position a.c. electrode, Murex Type A, for electric welding has been developed by *Metal Thermit Corp.*, 120 Broadway, New York. Overhead and vertical welds can be made without highly specialized welding technique. It meets various specifications of A.W.S., A.S.T.M., U. S. Navy Bureau of Ships, and American Bureau of Shipping. Sizes are: 3/32, 1/8, 5/32 and 3/16 in. Typical properties are: yield point, 52,000 to 61,000 per sq. in.; ultimate strength, 62,000 to 71,000 per sq. in.; elongation of 22 to 26 per cent in 2 in.

Lubricant for Metal-Cutting Saws

A new lubricant for the sawing of metal, Doall Saw Eez, has been developed by the *Doall Co.*, Des Plaines, Ill., being designed to withstand extreme pressures, minimize scoring and heating of the saw, and produce a smoother cut.

The company tells about tests made with cutting of oil hardening tool steel, with results that "Saw Eez" was used superior to work unlubricated. The Doall lubricant also may be used on lathe centers, hack saws, circular saws and other bearing surfaces that require intermittent applications of a tough film lubricant.

● A complete line of standard and specially designed vapor and solvent degreasers has been added to the products of the *Magnus Chemical Co., Inc.*, Garwood, N. J. Known as "Phillsolv," they use the inhibited tetrachlorethylene solvent. These degreasers are air-cooled, allowing the machine to be portable. Since tetrachlorethylene boils at higher temperature and has higher density, it is more effective in cleaning, safer, more agreeable to work with and cheaper.

Extruded Rubber for Compressible Sealing

The *B. F. Goodrich Co.*, Akron, Ohio, has succeeded in making extruded parts from its Ameripol synthetic rubber, which has a durometer reading of only 35 — five points less hardness than any natural rubber compound the company has extruded. Its first application, in aircraft, has been as a compressible sealing device between metal panels where there must not be the slightest air seepage.

It has a tensile strength of 700 lbs., elongation of 700 lbs., and can withstand cold down to —40 deg. F. without cracking. It is expected to find many industrial uses where compounds having higher durometer readings do not compress readily enough to give a desired air-tight or liquid-tight seal. It is only slightly affected by kerosene and benzene.

Box-Type Heat-Treating Furnace

A new heat-treating box-type furnace has been added to the line of "Falcon" furnaces, built by *H. O. Swoboda, Inc.*, Thirteenth St., New Brighton, Pa. This furnace, Type BRP-A, is suitable for continuous operating temperatures up to 2000 deg. F., and is available for all general heat-treating applications, in chamber dimensions up to 30 in. square by 4 ft. 6 in. deep.

It has a movable loading platform for charging and discharging; also, a push-button controlled, motor-operated door opening and closing mechanism. A heater cut-out feature automatically connects and disconnects the furnace upon the door opening or closing.

The furnace has an excess temperature safety feature to prevent burn-out should the controls fail. Included is an "on-off" type pyrometer control with input regulator for varying the input, to secure any desired heating, holding and cooling program.

A time clock installation will turn on the equipment at any predetermined time desired.

● An air cooled electrode holder for heavy metallic arc welding jobs is announced by *Jackson Products*, Detroit. With ½-in. rods, intense heat frequently causes the welder discomfort and reduces efficiency. The new holder is cooled by air at 3 or 4 lbs. pressure, travelling the entire length of the lower tong and introduced by connecting the air inlet tube to the plant air line. It is made of copper alloy, with deeply slotted jaws that grip the rod tightly, holding at the correct angle.

Dust Collector for Magnesium

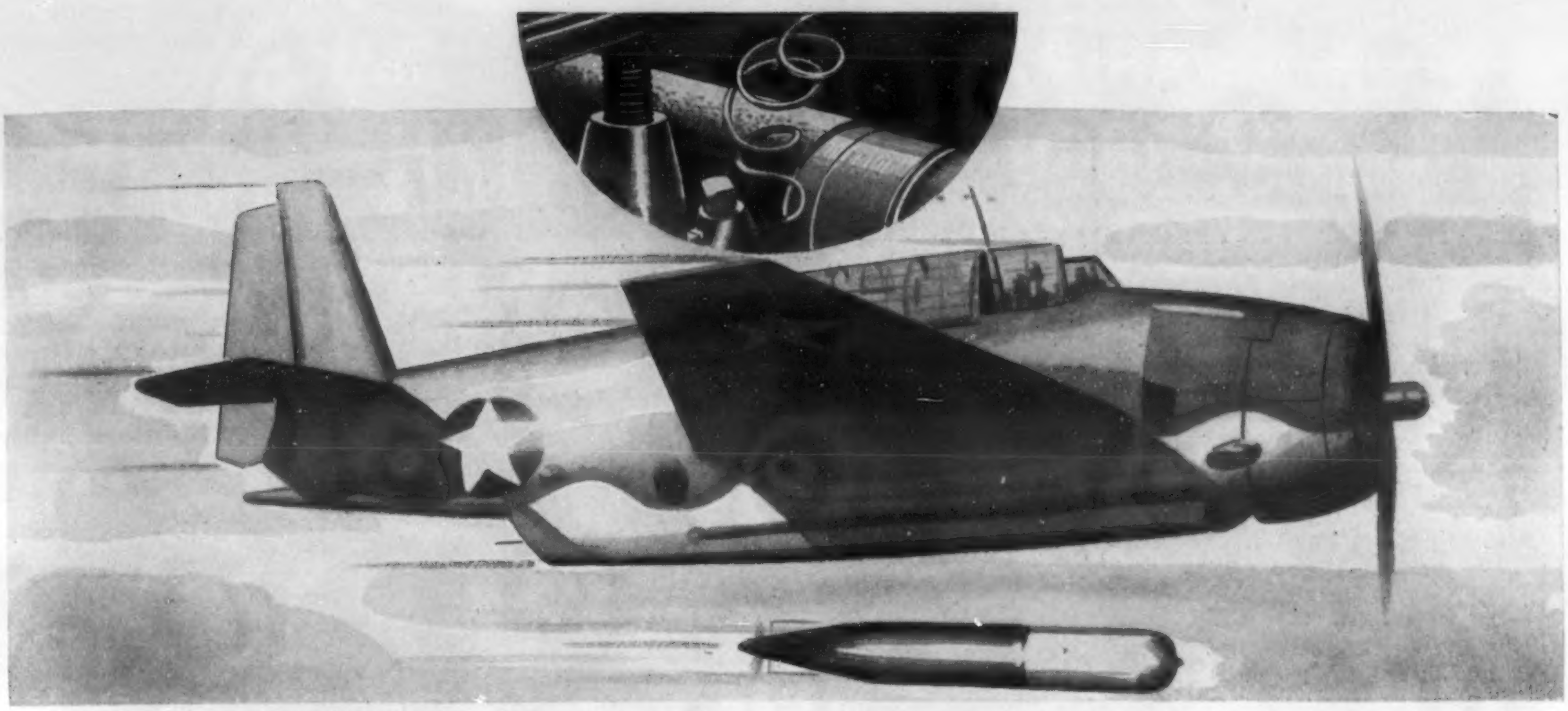
A new model of Hydro-whirl for dust collection in the processing of magnesium has been turned out by the *Industrial Equipment Corp.*, 625 East Forest Ave., Detroit. It contains only one movable part, a fan unit.

Units are available for use in either booth type or individual collectors for

grinding stands. Dust laden air is drawn through an orifice, causing a violent spray of water. Here the dust is "water-whirled" out of the air and is knocked down into a tank below, forming a sludge, which is removed easily.

The cleaned air returns to the room, resulting in less heat loss.

● New feature of an improved fume exhauster are that the fumes, gases, dust, filings and grinding compounds do not come in contact with the motor. Made by the *Chelsea Fan & Blower Co., Inc.*, it can be used in welding rooms, vaults, etc. The centrifugal type blower wheel is made of ⅛ in. thickness of steel with a 3 h.p. ball bearing motor. Adapters are interchangeable, to be used for suction or blowing.



More planes, ships, tanks and guns produced by tools that cut faster, longer

—*thanks to* "Certain Curtain" Hardening

The effectiveness of "Certain Curtain" control of furnace atmosphere has definitely raised the standard of tool steel performance. Tools are produced faster and with minimum spoilage; and they in turn give greater production output per machine and operator.

"Tool production increased 35% to 50% per furnace." — "Working life of tools increased one-third." — "Saving 20% to 35% of former tool cost." — Statements like these come from hundreds of plants. In fact, it would be hard to name a tool manufacturer, tool steel company, arsenal, or sizeable metal-working plant which does not rely upon "Certain Curtain" hardening for faster production of tools and dies whose quality means faster production of war materials.

Hayes furnaces are built to stand 'round-the-clock operation. Put them to work in your shop and get the MAXIMUM from your investment in tool steel, tool-making, and machine capacity!

P. S. *"Certain Curtain" furnaces are outstandingly successful hardening Moly and the other war-time steels.*

ELECTRIC CERTAIN CURTAIN FURNACES

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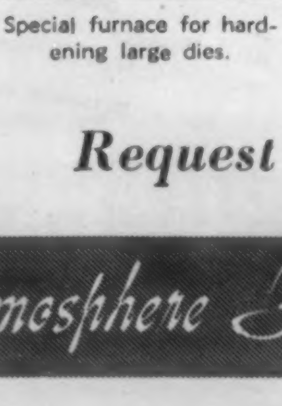
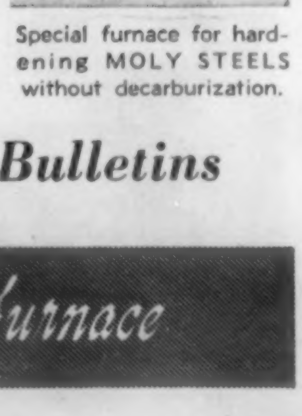
Standard furnace for hardening high speed steel tools.

Special vertical furnace for hardening large broaches up to 7 feet.



Special furnace for hardening large dies.



Special furnace for hardening MOLY STEELS without decarburization.

Request Bulletins

World's Leading Controlled-Atmosphere Furnace

Timer Applied to Belt Conveyor Furnace

A timer is usually used to measure elapsed time, but a recent application involves its use to measure elapsed distance in the travel in a belt conveyor furnace. Thus, the furnace can be loaded accurately to capacity, regardless of conveyor speed, with minimum attention from the operator, thus increasing furnace production.

The *General Electric* TSA-10 timer basically employs a Telechron motor that runs continuously and an electrically operated clutch, which when energized, connects the motor to the timing mechanism. At the end of the desired time, the time contacts close, giving a signal, or performing some other function.

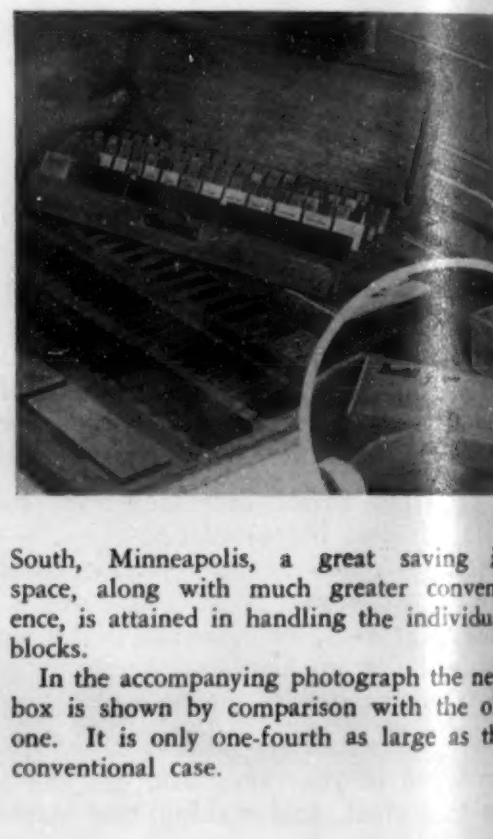
To measure elapsed distance, the motor is omitted and the mechanism is coupled to a rotating shaft in the conveyor drive. In the furnace application the timer was coupled to the drive drum of the conveyor. The clutch coil is energized when a load is put into the furnace.

When the conveyor has traveled the specified distance, the time contacts close, giving the operator a signal to put in a new load.

● A new "Thor" ¼-in. capacity electric drill, which is 14 per cent lighter in weight but packing more power per pound, is announced by *Independent Pneumatic Tool Co.,* 600 W. Jackson Blvd., Chicago. The field case, gear case and grip handle are of plastic, serving only as a protective armor and not supporting any operating part. It weighs 3¼ lbs., is 8 3/16 in. long, and is available in three speeds. It can be adapted to all types of heavy-duty production service in aviation plants, shipyards, etc.

Gage Blocks in More Convenient Box

One of the drawbacks to the use of gage blocks in the past has been the cumbersome case in which they were generally packed. With the new Doall box, made by *Savage Tool Co.,* 123 Fourteenth Ave.,



South, Minneapolis, a great saving in space, along with much greater convenience, is attained in handling the individual blocks.

In the accompanying photograph the new box is shown by comparison with the old one. It is only one-fourth as large as the conventional case.

Automatic Controller

A new instrument for automatically controlling temperature up to 3600 deg. F., flow, liquid level, pressure, draft humidity, pH value and time program has been announced by the *Bristol Co.,* Waterbury, Conn. It is called the Convertible Free-Vane controller. The new controller operates on the same basic principle used in previous models.

Several design refinements are incorporated into the new controller, however, which simplify the instrument and make it more convenient. The user can convert from one type of control system to another. It is offered in the following types: Monoset (on and off), Ampliset (throttling), Preset, Reset and Magniset.

Glass Tanks for Industrial Applications

A new line of glass tanks for industrial or commercial applications requiring a non-corrosive shock-resisting material has been introduced by the *Pittsburgh Plate Glass Co.,* Grant Bldg., Pittsburgh. They are made of glass throughout and built up to the required shape and size from heavy tempered glass plates.

The new tanks eliminate practically all former difficulties of glass tanks. A new method of heat treating gives to the glass a physical strength four or five times greater than ordinary glass. It has a high resistance to thermal shock, will withstand continuous operating temperatures of 650 deg. F., and an instantaneous thermal shock of 400 to 500 deg.

All joints are accurately ground, resembling the ground stopper of a chemist's bottle. The entire tank is surrounded by a wooden frame work filled with a compound, thus guarding against leaks and protecting against severe physical blows. The tanks are useful in electroplating and many other fields.

● Installation of 1,000,000-volt industrial X-ray equipment attained its second anniversary on April 1, comments *General Electric Co.,* Schenectady. On that day it had built up a record of more than 45,000 radiographs of heavy castings and forgings in its own laboratories, involving more than 8,000,000 lbs. of metal. The original X-ray tube had never needed replacement, though it had operated over 1400 hrs., with some exposures as short as 1 min., others as long as 1½ hrs.

Boots Protect Delicate Metal Parts

A shape-conforming jacket or boot for protecting super-finish and fragile parts in process through factories and packing for shipment has been developed by the *Metal Textile Corp.,* Orange, N. J.

Called "Metex Protective Boot," it is made with an outside sleeve of composite steel and cotton mesh with an interlining of all cotton mesh, which protects the parts from metal-to-metal contact, retains the oil film and excludes dust and foreign matter.

The boots will conform closely and cling to the contour of the parts, and can be

used where parts have heretofore been wrapped or taped. They can be used over and over again. They are made in all diameters and lengths.

● One of the most unique adaptations for war purposes of a standard device used frequently in metalworking is a grinding stone for the aviator on a rubber raft on the ocean to sharpen fish hooks. Item No. 13 in the aviator's kit is described as "a fish hook block holding spare hooks, wire leaders and sinkers at one end and at the other end a small Norton 38 Alundum stone cemented to the wood (hence non-sinkable) float for pointing fish hooks, grapple hooks and harpoon, and for re-sharpening his knife."

Infra-Red for Shrink Fit Assembly

Infra-red heat is often used to expand parts with which another part is to be mated. *Infra-Red Engineers, Inc.*, 812 Huron Road, Cleveland, has brought out the "Duplex Expander" and the "Endless Oven" for such purposes.

They will produce uniform expansions at variable temperatures from 200 to 360 deg. F. for shrink fit assembly of the following parts: taper, roller, ball, needle and other bearings and related housings; pistons and wrist pins; connecting rods and bearings; gears, hubs and shaftings; and bushings, sleeves and housings.

The manufacturer uses the Miskella insulated reflector, with which it is claimed that all of the advantages of infra-red heat are obtained with none of the previous disadvantages. Lamps are mounted on 5-inch centers, instead of the 10-inch centers usually used, thus producing far more concentrated heat energy. Insulated reflectors eliminate lamp base cement failures.

● Pipe and other threads are effectually protected in storage or transit against all damage, moisture, dirt, weathering, rust and corrosion by plastic pipe seal plugs made by the *American Molded Products Co.*, 1644 No. Honore St., Chicago. They are made in five standard sizes: 3/8, 1/2, 5/8, 3/4 and 1 in., with other sizes available on application.

Copies Directly from Blueprints

The Apeco Photocopy machine produces perfect photocopies of anything printed, written, typed, drawn or photographed, and no great skill is needed for its operation.

The engineering department uses it to make copies directly from blueprints without first making tracings, to copy specifi-

cations, and to duplicate every type of paper work. It is made by the *American Photocopy Equipment Co.*, Dept 173, 2849 No. Clark St., Chicago.

Measures Toughness of Surface Finishes

To measure toughness quality of surface finishes and their ability to resist digs, scrapes and similar abuse from actual service other than normal wear is the purpose of a new shear-hardness attachment for the Taber abraser, made by the *Taber Instrument Co.*, No. Tonawanda, N. Y.

A weight slides along the calibrated beam until it is located in the position where the correct load permits the tool point to cut a groove in the surface finish without digging through to the base plate. The most representative of several grooves is selected to measure to the nearest thousandth of an inch, a micrometer making the measurement.

Shear-hardness is calculated by taking the reading from calibrated beam at the forward edge of the adjustable weight which, together with the width of groove, determines the result by a mathematical formula. Only a sample, 4 in. square, is needed for the test.

The Taber abraser accurately evaluates resistance of surface finishes to rubbing abrasion.

High Speed Steel Hardening Furnace

A new vertical high-speed steel hardening furnace has been brought out by the *Sentry Co.,* Foxboro, Mass. Known as Size 4B, Model "YP," it is similar to the Size 2B, Model "Y" furnace, but it has a greater capacity, both as to tool diameters and lengths. The shell is made of steel, with heavy top and bottom plates. It will attain a top temperature of 2500 deg. F., tests showing that 1 hr. and 15 min. is needed to heat from room temperature to 2350 deg. F.

Heating elements are Globars, spaced on both sides of the muffle to provide even heating. The full muffle chamber is of silicon carbide, with inside dimensions of 6 x 6 x 40 in. and readily removable. The door is so arranged that the operator is not exposed to the hot surface.

This furnace was developed especially for use with the Sentry Diamond Block method of atmospheric control for high-speed steel hardening, and is claimed to have simplicity of application and high quality and cleanliness of product. Tools up to 4¾ in. in diam. and up to 36 in. long can be accommodated.

Molding Machines for Light Alloys

Manufacturers planning to adapt their foundries to the casting of newer magnesium and aluminum alloys may use the same type molding machines as those now used for iron and steel, with only minor adjustments, states Russell F. Lincoln, sales manager of the machine division, *Osborn Mfg. Co.,* Cleveland.

A minor change in the adjustment of the jolt blow to produce the required hardness of the mold is necessary. The molding of light alloys involves special consideration of the type of pattern and a proper type of molding sand, rammed to the right degree of hardness.

Marked changes have to be made in gating the mold and in the pouring technique. In many places machines in use for 25 years have been adapted to the newer metals.

● Landing gear struts for airplanes are chromium plated twice as fast with "Lucite" methyl methacrylate resin to protect the treated end during plating, states *E. I. duPont de Nemours & Co., Inc.,* Wilmington, Del. Experts have found it more durable than other insulating material in chromium electroplating baths. Rubber, lacquered wood, certain phenol-formaldehyde plastics, etc. contaminate the solution. *Thomas-Thiel Co.,* Wilmington, Del. forms the insulators.

Portable Dust Collector

A new portable dust collector, "Safe-Aire," has been developed by the *Bargar Sheet Metal Co.,* 12401 Euclid Ave., Cleveland. It is designed to provide a simple, flexible and inexpensive system.

Its basic use is to collect dust from a single grinder, or other dust-making machine, separate the dust from the air and blow the clean air directly back into the shop. It will normally handle the dust from two 9-in. grinding wheels, has a capacity of 600 c.f.m., and returns air to the shop 97 per cent clean and slightly warmer than before.

It is powered by a ⅛ h.p. motor running an Ilg blower at 3400 r.p.m. Spun glass filters, of standard size, inexpensive and easy to obtain, are the only parts that require periodic replacement.

● A flux that breaks down lead-rich solders into an absolute fluid that will flow into inaccessible places is claimed for Lloyd No. 6 Soldering Fluid made by *Lloyd S. Johnson Co.,* 2241 Indiana Ave., Chicago. It is excellent for soldering zinc-coated sheet metal, lead-coated sheet, tin plate, terne plate, brass, copper, steel and all types of sweat fittings. It can be diluted with one to two parts of water.

Aluminum Heat Treated Patents Expire

Aluminum Co. of America, Pittsburgh, announces the expiration of two of its patents covering heat treatment of aluminum alloy castings, which are particularly important to the aircraft industry in connection with the casting of high strength structural parts, structural fittings, crank cases, cylinder heads and small engine parts.

Two types are involved: One, an aluminum-base alloy casting containing silicon; the other, the same, containing between 3 and 5.5 per cent copper. A solution heat treatment is used in both types, with or without a subsequent aging treatment.

The procedure involves heating the castings to a temperature just under the melting point of the metal (from 950 to 1000 deg. F., depending on the alloy) and holding the casting here long enough to permit the soluble constituents of the alloy to go into solid solution. The casting is quenched, usually in water, and artificially aged at an intermediate temperature around 310 deg. F.

Licenses are royalty free for the war's duration. Complete information is at the disposal of interested parties, and booklets containing detailed data pertaining to the various methods of heat treatment involved are available to all licensees. Patent numbers are 1,508,556 and 1,572,487.

Multi-Purpose Washing Machine

A new portable multi-purpose washing machine for cleaning a wide range of large and small metal parts is announced by Washing Machine Div., *Magnus Chemical Co.,* Garwood, N. J.

Manufactured in three sizes, the parts to be cleaned may be handled by three methods: If small and/or delicate, they are handled in bulk (in baskets); if large, individually on the lower platform; or they may be hung on racks on the solution. The machine provides agitation of the parts by an up-and-down motion, thirty 8-in. movements per min.

Shell Trimmer for Forge Plant

A machine for trimming the crop ends of shell forgings is introduced by the *Yoder Co.,* 5500 Walworth Ave., Cleveland, the maker claiming that it saves much labor time, shipping charges and scrap handling. In developing the machine, the Yoder Co. collaborated with the *Dresser Mfg. Co.,* Bradford, Pa.

By trimming the crop end of the shell forging while it is still hot at the forge plant, this shell trimmer saves the cost of shipping the end cut off. The shell is cropped at forging temperature and the machine is preferably set in the forge line following the final sizing operation. A production of 270 cuts per hr. on the 105-mm. shell can be realized.

The machine is nearly automatic, the hot forging being slid from the conveyor over the mandrel. Cutter life is usually good, so that continuity of operation can be maintained.

● No-Fog prevents lenses from fogging and is suitable for welders' goggles, other goggles, eye glasses, gas masks and windshields. It is made by *Carhoff Co.,* 3050 Kensington Road, Cleveland.

Armor Plate Straightening Machine

To handle and straighten armor plate, the *Voss Machinery Co.,* 2882 W. Liberty Ave., Pittsburgh, has brought out an improved Voss Ungerer roller leveler, which performs a new and wider range of plate straightening work. It is not only of heavier construction, but is of improved design.

It takes care of ¾ in. armor plate, in continuous sheets, and up to 1 in. in some other steels. It can also be designed and built for much heavier and wider plates.

Tungsten Filaments by Powder Metallurgy

Interesting applications of powder metallurgy are related by the *Westinghouse Electric & Mfg. Co.* Technicians are now fashioning small magnets for electrical circuit breakers — automatic switches controlling the flow of power in war plants and aboard naval vessels.

Another variation is the making of tungsten filaments in electric lamps. Tungsten ore, a coarse brown powder, is chemically treated to convert it into a yellow tungstic oxide, also a powder. This is put into metal "boats" and placed in air-tight steel pipes enclosed in gas-heated furnaces. The "boats" are moved forward through the pipe into increasingly higher temperatures while hydrogen gas flows over them, thus removing all water and oxygen and leaving pure tungsten powder.

The powder is then squeezed with pressures of 20 tons per sq. in. to form it into a 2-ft. long bar, less than ½ in. thick. The bar is baked in a hydrogen-filled metal "bottle" while an electric current is passed through it. For the first time, it takes on a metallic appearance.

Next, the bars are heated and hammered into rods that can be drawn into wires one-fifth the thickness of a human hair. In the last stages, the tungsten strands are pulled through tiny holes in diamonds so that the metal crystals are elongated and plaited into one another.

This material is stronger than the highest grade of steel in bridges and skyscrapers. An inch square bar can stand a pull of 250 tons, as against yield point for structural steel of 100 tons.

Ring Style Holder for Stamping

A new line of ring style holders, designed for curved line marking of all types of parts, from ¼ in. to 6 in. in diam., is being introduced by *James H. Matthews & Co.*, 3942 Forbes St., Pittsburgh. They are either for high-speed production stamping equipment or for hand-style units where marking of parts may be limited.

It is economical for use with segment type, which is engraved with one character only, or logo dies, engraved with two or more characters, from 1/32 to ½ in. in size. They are provided with dovetail self-locking segment type for positive holding, a quick and easy changing type.

Multiple Inspection Gages

A series of multiple inspection gages has been brought out by *Federal Products Corp.*, 1144 Eddy St., Providence, R. I., which check several diameters simultaneously. They are entirely mechanical and require no electrical connections.

Model 247 B-76 checks in one operation five entirely separate dimensions on a fuse body. The movement of each sensitive contact is transmitted directly to each dial indicator point through a pantograph unit.

Model 236 B-123 is designed to check simultaneously the various diameters of a rotor shaft. The shaft is mounted between centers so that it can be rotated, permitting all the diameters of the rotor to be checked easily.

Model 247 B-72 is designed to check simultaneously ten dimensions of a cylindrical sleeve — eight diameters and two lengths. These should not be confused with multiple inspection gages for checking concentricity.

Metal Used for Propeller Castings

Meehanite metal has replaced brass in the production of propeller castings for U. S. Coast Guard vessels at the Grove City, Pa. foundry of the *Cooper-Bessemer Corp.* These difficult one-piece, three-bladed propellers have passed rigid inspection and testing.

Conversion to Meehanite is said to have reduced propeller production costs as much as 50 per cent, in addition to conserving critical brass. Cooper-Bessemer metallurgists had previously adapted Meehanite to the manufacture of Diesel engines, gas engines, compressors and other equipment for marine and industrial purposes.

Crane Parts Salvaged from Four States

A heavy-duty, 20-ton overhead crane, built from scrapped and salvaged parts by the Oakland Maintenance Div., *General Metals Corp.*, is now in operation in the company's Iron Plant Div., Oakland, Calif. Its construction saved an 18-months' production delay threatened by the late delivery of a vitally needed crane.

The overhead beams were from an abandoned power house of the Utah Power and Light Co. Power is supplied by a Westinghouse motor salvaged from a deserted rock quarry in Nevada. Power for the hoist is furnished by a General Electric motor from a damaged crane at Shasta Dam in Northern California. A second General Electric motor from a lumber mill in Washington operates the trolley drive. The hoist brake comes from an old gold mine hoist in Angels Camp, Calif. The limit switch contactor is from an old General Electric welder in Southern California.

When necessary parts could not be found, they were fabricated at the Oakland plant. End trucks, hoist and control equipment were all designed, engineered and fabricated. Secondary resistors were assembled from salvaged parts found in the shop. Hoist drum, sheaves and gear were designed, patterned and cast. The load hook was forged at Los Angeles.

The crane is affectionately called "Big Scrappy."

Application of Sprayed Metal Coating

A new low-cost rapid means of applying a protective metal coating to metal assemblies, of re-coating areas burned by welding, of patching or repairing small areas in large galvanized assemblies where the coating has been damaged, and of providing an ideal base for painting, is announced by *Alloy Sprayer Co.*, 2040 Book Bldg., Detroit.

The originator claims that an actual tinning of the sprayed metal with the base metal has been effected. Often sandblasting or other preparation of the surface is not necessary. The operation is merely spraying the surface with a coating of Galv-Weld metal by an Alloy-Sprayer gun, which is a portable, self-contained "gun type" unit, having a thermostatically controlled metal melting pot and a means of atomizing and spraying the melted metal. It is operated by air pressure.

The thickness of the coating will be from .001 to .008 in., depending on the degree of resistance to corrosion required.

● Scaiflux 21, a silver alloy brazing flux, has been made available to users of silver alloy brazing by *Scaife Co.*, Oakmont, Pa. It is a low-surface tension flux, developed through a Mellon Institute Fellowship. The maker claims that it speeds production, cuts cost, simplifies silver alloy brazing and is useful for brazing any type of ferrous or non-ferrous alloy. It is fully active at 900 deg. F., and remains stable and active at above 1650 deg. F. It is soluble in 140 deg. F. water.

Rubber Bonded to Welded Steel

A method of bonding solid sheets of Koroseal directly to the welded steel, wood, or concrete of tanks is announced by *B. F. Goodrich Co.*, Akron, Ohio. Koroseal is a plasticized polybinyl chloride whose qualities are superior to rubber in many places. It has remarkable corrosion resistance, such as with chromic and nitric acids.

However, the material has certain limitations both in temperature ranges and effects of various chemicals on it. The sheets are three times thicker than an earlier type.

Among its advantages are: It can be applied in thicknesses to 3/32 in., inclusive; it is not subject to physical damage and pin hole leaks suffered by many corrosion resistant paints, but will not withstand physical abuse and metallic gaging; it is more resistant to abrasion than corrosion-resistant paint films; it is readily repaired when damaged; it has high electrical resistivity; it can be easily tested for leaks with an electric tester; it is highly resistant to oxidation, water, sunlight and gas diffusion.

News of Men, Societies, Meetings and Companies

Plants and Slants

Bins, specifically designed for storing scrap (and other materials) have been incorporated in *Walworth Co.'s* new mid-West plant. Slatted doorways were placed, not at the center, but at one corner of each bin, which was cut off diagonally for that purpose. Situated on corners facing each other, the doorways form a "V" into which a loading truck can back on a diagonal for either bin, permitting maneuvering in the narrow roadway. The corner doorways also take advantage of the tendency of material deposited from overhead to form conically and leave waste or free corner space in a square bin. This scrap furnishes a nearby foundry. *Rust Engineering Co.* collaborated in the lay-out.

Scrap Bins: 1943 Model

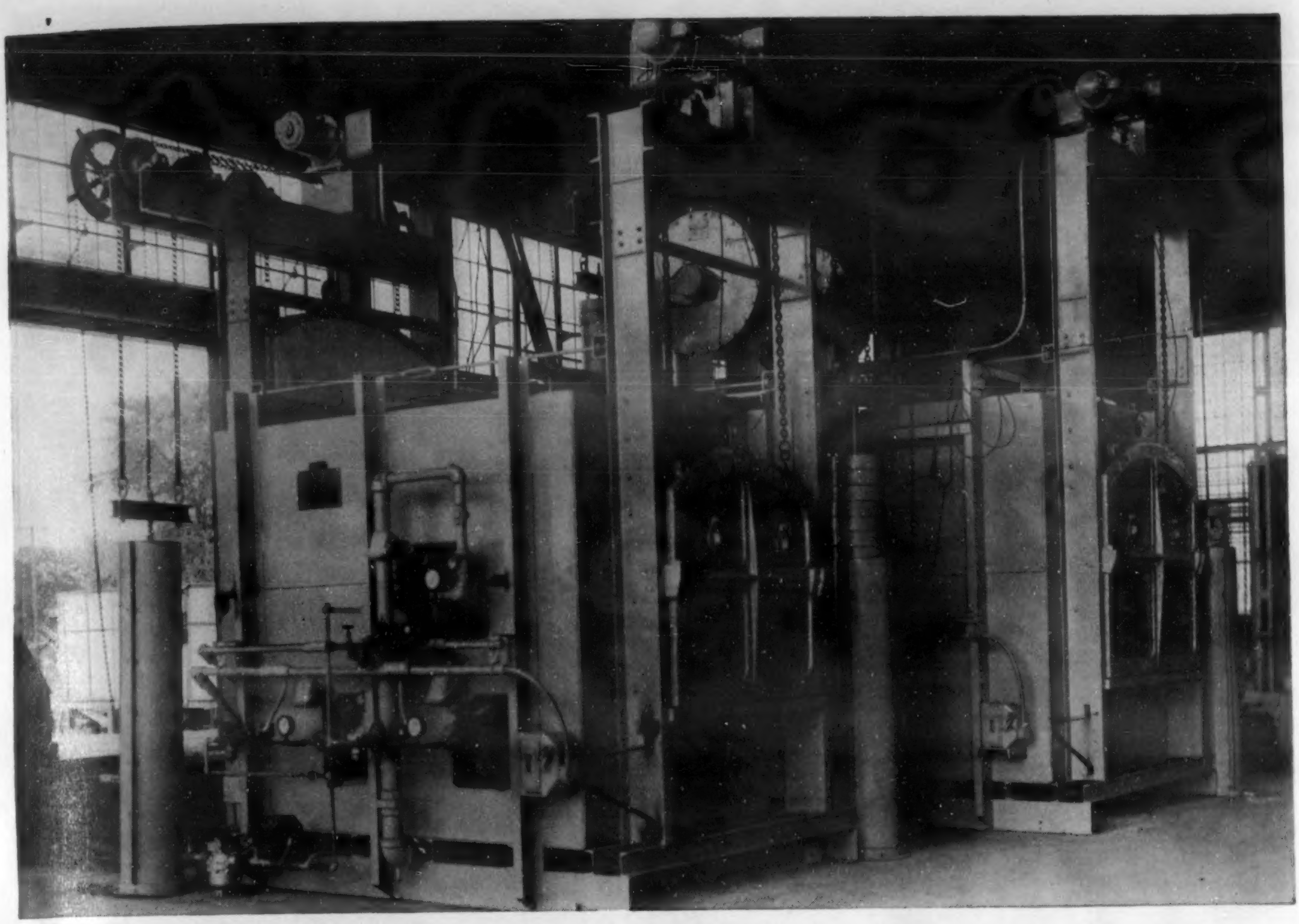
Instead of the golf club, they'll swing a hoe; instead of whacking a gutta percha ball, they'll swat Mexican bean beetles. In short, officials of the *Ilg Electric Ventilating Co.*, Chicago, have plowed up the employees' golf course and divided it into plots for "Victory" gardens. A golf expert had called it "the most interesting short course in America." Nine holes totaled 511 yards, with a par of 25 (the new par will be 25 carrots per 3 ft.). Plant employees voted to garden instead of golf. The golf course sprinkling system will be left intact for watering purposes.

The Erie Works, *General Electric Co.*, which claims already to be the possessor of every production award bestowed by the Government, received an additional honor, the Army-Navy "E" pennant with three stars.

A record-breaking total of 1,437 railroad cars loaded with finished war products rolled out of the East Pittsburgh Works of the *Westinghouse Electric & Mfg. Co.* in February, it was divulged during the ceremony involving the receipt of the Army-Navy "E" burgee with white star.

Taylor-Wharton Iron & Steel Co. has awarded the company's 50-year medal to L. N. Aller, bringing the total to 15 men now living who have received that medal for a half century of service.

America's largest propeller plant, property of the *Curtiss-Wright Corp.*, Propeller Div., has just swung into full production "somewhere in Indiana." Called the most completely conveyorized propeller



Recently installed in large manufacturing plant — **Two double end oil fired underfired Heat Treating Furnaces**

DREVER

DEPENDABLE HEAT TREATING FURNACES

DEPENDABILITY BASED ON:

1. Sound engineering
2. Rugged construction
3. Oil, gas or electric heating as indicated by requirements
4. Efficient material handling equipment
5. Proper type of control
6. Conservative production rating
7. Efficiency of operation and predictable quality of heat treated material.

★

The following descriptive Bulletins on typical Drever Installations are available upon request.

B-3 Industrial Furnaces

B-4 Bright Annealing Stainless Steels

B-5 Ammonia Dissociation Equipment

EXPERIENCE POINTS TO THE DREVER CO

THE DREVER CO.
750 E. VENANGO ST.
PHILADELPHIA, PA.

plant in the nation, it is equipped with miles of conveyors that have eliminated the old method of trucking production materials within the plant.

A feature of the Army-Navy "E" ceremony booklet of *Leeds & Northrup Co.*, Philadelphia, is that it is devoted almost entirely to employees, showing photos of group after group in every-day scenes.

Talon, Inc., Meadville, Pa., maker of slide fasteners, recently purchased controlling interest in the stock of *Electroweld Steel Corp.*, Oil City, Pa., which makes pressure and mechanical steel tubing in resistance weld tube mills.

The Meehanite Metal Corp. and the *Meehanite Research Institute of America, Inc.* have moved headquarters to Pershing Bldg., New Rochelle, N. Y. from Pittsburgh.

Mitchell-Bradford Chemical Co., Bridgeport, Conn., will be represented as to their protective coatings department in Michigan, the Far West and in other centers by Tom Collord.

Meetings and Expositions

American Gas Association, joint production and chemical committee conference. New York, N. Y. May 24-25, 1943.

National Metal Trades Association, production conference. Chicago, Ill. May 26-27, 1943.

American Iron & Steel Institute, general meeting. New York, N. Y. May 27, 1943.

Society of Naval Architects & Marine Engineers, spring meeting. Bath-Portland, Me. May 27-28, 1943.

American Society of Refrigerating Engineers, spring meeting. Cleveland, Ohio. June 1-2, 1943.

Society of Automotive Engineers, Diesel engine, fuels and lubricants meeting. Cleveland, Ohio. June 2-3, 1943.

Society of Automotive Engineers, war material meeting. Detroit, Mich. June 9-10, 1943.

American Society of Mechanical Engineers, semi-annual meeting. Los Angeles, Calif. June 14-16, 1943.

American Institute of Electrical Engineers, national technical meeting. Cleveland, Ohio. June 21-25, 1943.

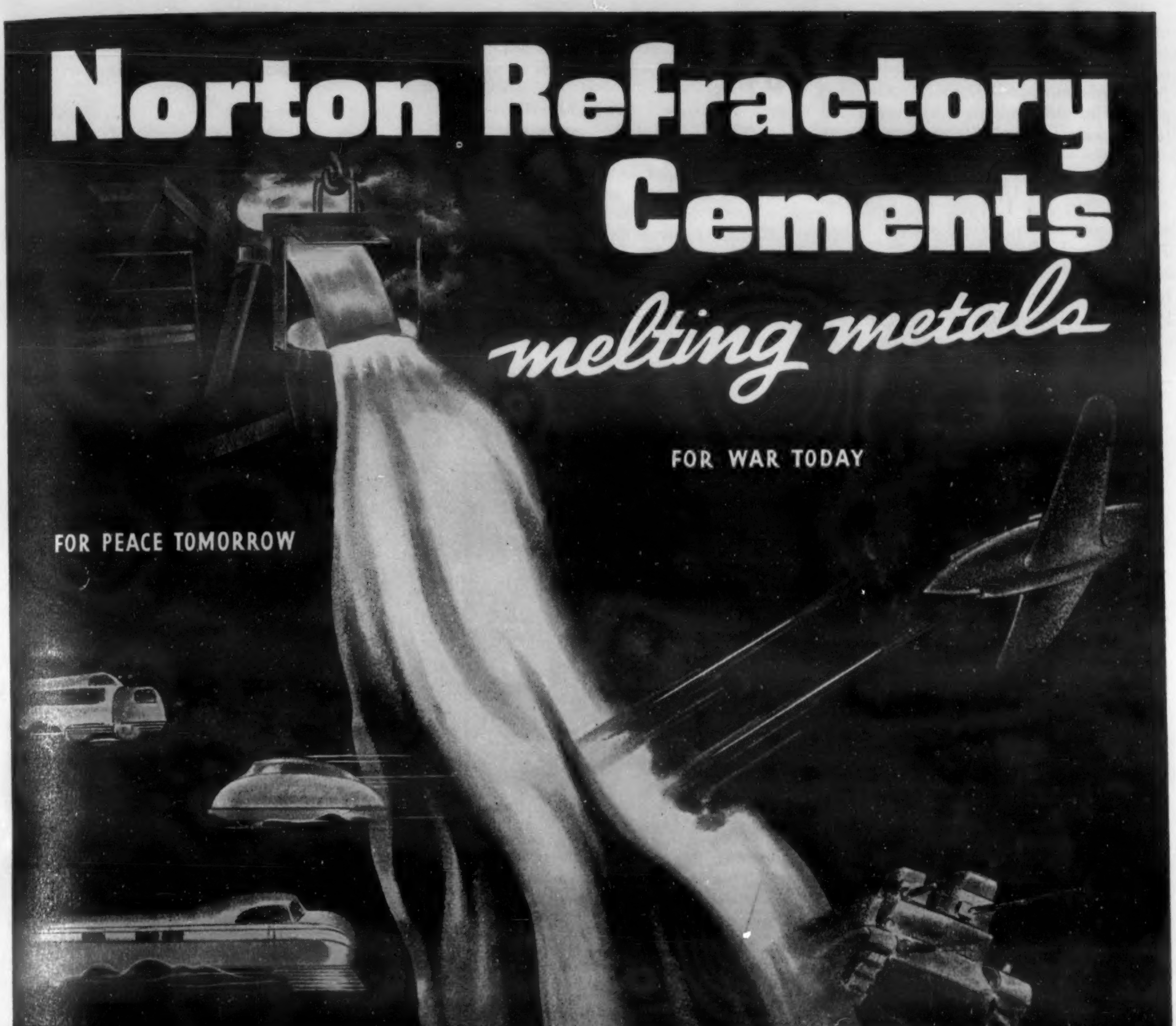
American Society for Testing Materials, annual meeting. Pittsburgh, Pa. June 28-July 2, 1943.

Briefs on Associations, Promotions, Education

Letters from soldier-employees appealing for more production, and reproduced as plant posters, is the latest approach employed by *Lukens Steel Co.*, Coatesville, Pa., in its morale-building campaign. The posters carry photos of former Luken employees now on active duty with our armed forces and excerpts from their letters, such as: "Some day that steel may save our lives. Keep up your good work." There is nothing so blunt or raucous in the posters as: "Get out there and produce!"

Palladium is being described as "platinum's twin sister" in a national educational campaign to build consumer acceptance for this rare white precious metal, which is now in the forefront in the jewelry field due to war restrictions on platinum. Two palladium medals were awarded to college and high school winners of the Thomas Jefferson Bi-Centennial oratorical contest which closed April 13.

The "Pearl Harbor Vengeance Legion" is a new employee organization of the *Westinghouse Lamp Division*, Bloomfield, N. J., to fight absenteeism. Membership



This is a war of metals with aluminum, copper, steel and their alloys playing vital roles. And Norton Refractory Cements are being chosen to line metal melting furnaces. Made to withstand severe conditions at high temperatures, Norton Refractory mixtures, for either ramming or troweling, give long service. In tomorrow's peacetime competition between metals and new structural materials like plastics and plywood Norton will continue to serve the metal melting industry with Refractory Cements that give longer lining life.

NORTON COMPANY, Worcester, Mass.

Norton ELECTRIC FURNACE FUSED **Refractories**

is open to those who have been neither late nor absent for one year following the Jap attack on Pearl Harbor. Almost 6 per cent of the employees achieved a perfect attendance record during the past year.

A modified design of freight car journal bearings may result in the reclamation of many thousands of tons of critical metals. The standard journal contains 25 lbs. of bronze, and 14,000,000 are estimated to be in service, able to yield thousands of tons of copper, lead, tin and antimony, if tests on the modified design prove out. So stated C. C. Bailey of General Electric Co.'s transportation department recently.

The Electric Metal Makers Guild, Inc. will hold its annual meeting at Canton, Ohio, June 4 and 5. Two groups, Castings and Ingot Divisions, will meet separately at times, and at other times together. Co-chairmen for the meeting are Walter Farnsworth, Republic Steel Co.; Leroy Bash, Timken Steel & Tube Co., and Chester Williams, Massillon Steel Castings Co. At a sectional meeting scheduled for May 1, it was planned that melting foremen, melters and first and second helpers on electric furnaces attend the technical sessions.

The American Brush Manufacturers Assn. has elected as president Norman F. Smith, vice president and general manager of the Osborn Mfg. Co., Cleveland.

College graduates employed by General Electric and associated companies number 9222 and comprise 5 per cent of all men and women employees. They are from 325 domestic colleges and from foreign colleges in 34 different countries.

Directors of the Wire Association elected as president Carl Johnson, superintendent, Rod and Wire Mills, Bethlehem Steel Co., Sparrow Point, Md.

The Electrochemical Society, Inc. has elected as president R. M. Burns, Bell Telephone Laboratories, New York.

News of Metallurgical Engineers

Bradley H. Booth has joined Carpenter Brothers, Inc., Milwaukee, as foundry engineer, having previously been with Jackson Iron & Steel Co., Jackson, Ohio. The Carpenter company is a producer and distributor of foundry sands, clays, refractories and steel abrasives. In his previous connection, Mr. Booth worked chiefly on pig iron.

Douglas C. Williams, formerly with the research laboratories, American Steel Foundries, East Chicago, Ind., has been appointed to the fellowship at Cornell University, maintained by the American Foundrymen's Assn. for study of properties of foundry sands.

F. O. Cooper has been appointed manager of the Sheet and Strip Bureau, Metallurgical Division, Carnegie-Illinois Steel Corp., Chicago district. He joined the U. S. Steel Corp. in 1905, and affiliated with the metallurgical department in the Chicago office in 1935.

Bernard F. Nemerguth has been appointed service manager of the Tocco electrical induction heating and hardening equipment division, Ohio Crankshaft Co., Cleveland, having formerly been chief test engineer.

William L. Batt, vice chairman WPB and president of SKF Industries, Inc., Philadelphia, has been tendered the Bok award — a medal and a $10,000 check — for leading industrial mobilization of the war and for being the citizen who performed the most distinguished service for Philadelphia in 1942.

Dr. Charles M. Slack, well-known research chemist, has been appointed assistant director of research at the Westinghouse Lamp Division, Bloomfield, N. J. He has specialized in electronics research and has helped to develop an ultra high-speed X-ray machine that is making possible the

studies of bullets as they crash through armor plate.

H. L. Trembicki has been appointed manager of the newly-organized Wire Coating Division of Magnus Chemical Co., Inc., Garwood, N. J. He has had a wide range of experience in the metal-working and wire-drawing industries, and developed a process for drawing wire without use of lime.

Dr. Edgar C. Bain has been appointed vice president in charge of research and technology of Carnegie-Illinois Steel Corp. This is a new vice presidency. Dr. Bain is best known among metallurgists for his studies of stainless steel, hardening steel and influence of various alloys upon properties of modern constructional steels. He has received several medals and honors, is an author and is widely consulted. He joined U. S. Steel in 1928.

Robert K. Kulp has been appointed director of research by the Jessop Steel Co., Washington, Pa. He was formerly with the Steel & Tube Div., Timken Roller Bearing Co., as research metallurgist. Previous to that he was with Lukens Steel Co., in the same capacity.

Willard H. Dow, president of the Dow Chemical Co., has been awarded the Charles Frederick Chandler medal by Columbia University for noted achievements in chemistry. The citation described as "spectacular" the achievements of his company in producing bromine and magnesium from sea water and of synthetic plastics and rubber.

Dr. George H. Spencer-Strong has been appointed director of research of the Porcelain Enamel & Mfg. Co., Baltimore. He succeeds *Lyman C. Athey*, who resigned to become vice president of the International Products Corp.

Edgar N. Yost has been made division superintendent of the new armor plate plant, which is part of the Gary Works, Carnegie-Illinois Steel Corp. He joined the Gary plant in 1916 and has been engaged chiefly in inspection work.

William C. Fork, formerly superintendent of the hot strip rolling mills, Acme Steel Co., Chicago, has become general superintendent of the Riverdale plant. *Walter F. Hinkle*, assistant hot mill superintendent, will succeed Mr. Fork.

Dr. Ancel St. John is with the Ordnance Dept., Washington, D. C. as senior metallurgist, on leave from St. John X-ray Service, Inc.

Le Roy L. Wyman, metallurgist for 19 years with the research laboratory of the General Electric Co. at Schenectady, has been released by his company for the emergency to join the staff of the War Metallurgy Committee, National Academy of Sciences, National Research Council. He has worked on hard carbides, steel treatment, heat-resistant alloys and refractory materials.

Dr. Walter Savage Landis, vice president, American Cyanamid Co., has been awarded the gold medal of the American Institute of Chemists. He was graduated from Lehigh University in 1902 as metallurgical engineer, and studied mineralogy and crystallography at Heidelberg, Germany. He has developed processes for production of hydrocyanic acid, cyanides, ferrocyanides, dicyandiamid and urea from cyanamid.

Frank J. De Rewal, former research chemist for the Foote Mineral Co., Philadelphia, has been appointed to the research staff of Battelle Memorial Institute, Columbus, Non-ferrous Metallurgy Division. *George K. Manning*, metallurgist at the Chicago plant of Republic Steel Corp., will do metallurgical research for Battelle.

books

FOR METALLURGICAL ENGINEERS

Wrought Stainless Steels

TABLES OF DATA ON CHEMICAL COMPOSITIONS, PHYSICAL AND MECHANICAL PROPERTIES OF WROUGHT-CORROSION-RESISTING AND HEAT-RESISTING CHROMIUM AND CHROMIUM-NICKEL STEELS. *Prepared by Russell Franks and Francis L. LaQue. Published by the American Society for Testing Materials, Philadelphia, 1942. Paper, 6 x 9 in., 44 pages. Price $1.25.*

This is a pamphlet which has been eagerly awaited for some time. It is an important and timely collection of carefully prepared data on the chemical compositions, physical and mechanical properties of the wrought high chromium and nickel-chromium steels.

Sponsored by Committee A-10 of the American Society for Testing Materials, it has been prepared by its Sub-Committee I. The work has been done by two members of this sub-committee, as indicated.

The steels included in the report are those that are in the widest commercial use and the data are presented in two parts. Part I covers the wrought chromium steels up to 4 to 6, 8 to 10 per cent Cr, etc. Part II covers wrought chromium-nickel steels up to 25 Cr, 20 per cent Ni.

The data are presented in the form of compact tables and charts. There are 21 tables and 26 charts which cover forging and heat-treating practice, mechanical properties, creep information and short-time tensile properties, besides chemical composition and physical characteristics.

Two other publications of this nature have been presented by the Society, one in 1924 and the other in 1930. This latest one will prove of decided value to those who use these types.

—EDWIN F. CONE

Elements of Metallurgy

ELEMENTARY METALLURGY. *By W. T. Frier. Published by McGraw-Hill Book Co., Inc., New York, 1942. Fabrikoid, 5¾ x 8¼ in., 207 pages. Price $1.75.*

In recent years there has been an outpouring of metallurgical text books, primarily for college use. All contain nearly the same material, all are usable when accompanied by the clarification of lectures by a good instructor. Most of them are too advanced to be assimilated by the average person in home study, and many are pretty hard to digest even with the aid of lectures unless the student is rather mature. It might be good pedagogy to start the student with a sketchy smattering (a soup course) not expecting much of it to sink in at the start, and follow with the intensive study of a more comprehensive text (the heavy victuals). Texts for the soup course have been few.

Frier's little book was written for use in the General Electric Co.'s Technical Night School, at the Erie works, but might well serve as a conditioner in a college course, and if the student is approaching metallurgy on his own by home study with no instructor to help him, something of this type is essential.

We shall have to draft into metallurgy, for control and for inspection, many technicians to whom the subject is entirely new. A useful book on elementary metallurgy is therefore most timely.

No two authors or instructors would agree precisely upon what should be covered in an elementary text, nor does it matter very much, since the purpose is not primarily to teach facts and theories as it is to condition the student to grasp, from more advanced texts, the details of whatever particular phase of metallurgy his work will deal with. A thousand metallurgists could write as good an elementary text, but the other 999 haven't done it, and this text will serve its purpose nicely.

—H. W. GILLETT

Strategic Materials

STRATEGIC MATERIALS IN HEMISPHERE DEFENSE. *By M. S. Hessel, Walter Murphy and F. A. Hessel. Published by Hastings House, New York, 1942. Cloth, 5¾ x 8¼ in., 235 pages. Price $2.50.*

Many materials are discussed in this book which do not interest the metallurgical engineer but the data on many of the strategic and critical materials are fairly complete and presented by rather impressive charts. The discussion is divided into three parts. Part I includes Strategic and Critical Materials; Part II, Latin America; and Part III, Additional Materials—copper, lead and zinc, etc.

In Part I the "pearls of great price lost in the Far East"—rubber and tin—are discussed. The treatment of tin is quite general with statistics on imports and consumption. These, however, cover only through 1940. Chapter 2 in this section is devoted to "steel, heart and lifeblood of armaments." This is rather disappointing in that it deals mainly with the ores of manganese, chromium, tungsten, vanadium and so on. Here again the statistical data are not of very recent vintage. In a third chapter of Part I such materials as aluminum, mercury, antimony, platinum and mica are discussed.

Part II on Latin America is aimed to show the importance of the countries to the south of us as a source of several vital and active materials. The discussion is good and impressive.

In Part III only four pages are devoted to copper, lead and zinc, the balance being taken up with such subjects as petroleum; chemicals; and fats, oils and gums.

For metallurgical engineers the book is not of vital importance but for the general reader there are many things which are of value.

—EDWIN F. CONE

Other New Books

CONSTITUTION OF ALLOYS BIBLIOGRAPHY. *Compiled by J. L. Haughton. Published by The Institute of Metals, London, 1942. Limp cloth, 5½ x 8½ in., 163 pages. Price 3s. 6d.* This bibliography contains over 5,000 references to papers dealing with the constitution of binary, ternary and higher alloy systems, ferrous and non-ferrous. As a guide to the references, asterisks have been placed against those in the originals of which a new equilibrium diagram, or a portion of one, is to be found. The bibliography is intended to be used in conjunction with the abstracts that the Institute has published since its foundation. It is up to date and should prove invaluable to all research workers in metallurgy and to those interested in the constitution of metallic alloys.

REVERE WEIGHTS AND DATA—SIXTH EDITION. *Published by Revere Copper and Brass, Inc., New York, 1942. Paper 8½ x 11 in., 48 pages.* This handbook has been enlarged to contain 6 new pages covering definitions of technical and mill terms used in the copper and brass industry, as well as pictures to clearly illustrate those items not easily defined. All chemical and physical properties have been brought up to date. There have been included additional formulas for calculating weights and other formulas have been simplified. This handbook is available for selective distribution to executives, technical and research men and others, free for the asking, the only requirement being that the company be furnished with the title or position and the firm name of the proposed recipient.

William P. Winsor, *Vice President and Business Manager*
Advertising and Executive Offices: 330 West 42nd St., New York, N. Y.

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Duncan A. Scott & Co., *Mills Bldg., San Francisco, Calif.*
Duncan A. Scott & Co., *Western Pacific Bldg., Los Angeles, Calif.*

trends

By *Edwin F. Cone*

Steel Making Capacity

Each year and almost each month witnesses an increase in the country's steel making capacity. When the present program of expansion is completed, says the American Iron and Steel Institute, probably during 1943, the blast furnace capacity will be 20 per cent greater than it was on Jan. 1, 1938. Open-hearth steel capacity will be about 18 per cent greater, while electric furnace capacity will be almost 3½ times what it was at the beginning of 1938.

Finished Steel in 1942

The demands for steel from American consumers last year were largely concentrated on six major finished products, contrary to the trend in normal times. The products made in record-breaking tonnages, says the A.I.&S.I., were steel plates, structural shapes, hot-rolled carbon steel bars, alloy steel bars, and tool steel bars.

Steel Castings

Final estimated production figures for steel castings for 1942 show the trend toward expanded output kept up through the year. The total last year, according to Bureau of Census figures, was 1,664,211 net tons. This compares with 1,316,027 tons in 1941, and with only 797,947 tons in 1940. The 1942 total is more than double that of 1940.

Domestic Scrap Consumption

Estimates of domestic scrap consumption for 1942 are placed at 4,653,000 gross tons per month. In 1941 this was 4,469,000 tons and in 1940 it was 3,474,000 tons per month.

Buying Steel

A new trend in the methods of buying steel is reported by the American Iron and Steel Institute. Customers are specifying mechanical properties rather than stipulating precise chemical compositions. This innovation, stemming originally from shortages in alloying elements, is working out so satisfactorily that it may be widely adopted after the war is over.

Canadian Iron and Steel

Canadian pig iron and steel output reached new highs in 1942, as was to be expected. The pig iron total was 1,975,015 net tons which is 29.2 per cent over that for 1941, 50 per cent over 1940, and 134 per cent in excess of 1939. Output of steel ingots and castings last year at 3,121,361 tons was 15.5 per cent in excess of 1941, 38.3 per cent above 1940 and 137 per cent above 1939. These totals reflect war demand.

Steel Plates

Due to the demand for steel plates in the shipbuilding industry, the production last year rose to new heights. The output for sale was 11,543,000 net tons, which is an increase of 90 per cent above the previous record in 1941.

Machine Tools

The production of machine tools in 1942 reached the large total of $1,320,000,000 worth—a figure never before approached, according to *Machine Tools,* published by the Natl. Machine Tool Builders' Assn. The corresponding total for 1941 was $775,000,000. A measure of the growth of this highly important industry is afforded by the fact that in 1938 the value of the industry's output was only $145,000,000. In 5 yrs. the industry has expanded over 9-fold.

Electric Furnaces

According to data published by the *Iron and Steel Engineer,* there were 229 ingot making electric furnaces installed or under construction in the United States on Jan. 1, 1943. The estimated capacity is placed at 6,011,100 tons.

Besides these there are a large number of furnaces in the foundry industry. For both ingots and castings the number is constantly expanding.

Steel Foundry Capacity

By the end of 1943 there will be approximately 335 steel foundries in the United States with an estimated capacity of 3,154,000 tons. At the end of 1942 the industry had expanded to 320 foundries with an estimated capacity of 2,339,000 tons — all on the authority of George F. Hocker, chief, forgings and castings section of the WPB.